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VOSBURY, Newman Arthur, 1932-
A DATA RETRIEVAL SYSTEM WITH HIGH STORAGE EFFICIENCY AND A COMPUTER BASED INSTRUCTIONAL SYSTEM.

The University of Oklahoma, Ph.D., 1973
Information Services, information storage and retrieval systems

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THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

A DATA RETRIEVAL SYSTEM WITH HIGH STORAGE EFFICIENCY AND A COMPUTER BASED INSTRUCTIONAL SYSTEM

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

NEWMAN ARTHUR VOSBURY

Norman, Oklahoma

1973

A DATA RETRIEVAL SYSTEM WITH HIGH STORAGE

EFFICIENCY AND A COMPUTER BASED INSTRUCTIONAL SYSTEM

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ACKNOWLEDGEMENT

I would like to acknowledge the help and support of many people. In particular, Dr. Richard V. Andree has given much encouragement as a friend and teacher. The courses I have had from Drs. Payne, Gylys, Feyock, and Thompson have contributed much to my growth. Bev Dvorak has been most patient in typing the manuscript and very helpful in suggestions of form. Last, but not least, my family. My wife, Jane, has typed and proofread and put up with being a computer widow. My son, Larry, helped test the writing of lessons in SCRIPT.

Filmed as received

without page(s) iv .

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TABLE OF CONTENTS

Page

LIST OF TABLES vii

LIST OF ILLUSTRATIONS viii

CHAPTER

I. INTRODUCTION 1

Motivation for the project. Two components: an information storage and retrieval system (STRIPE) and a computer based instructional system (SCRIPT). Reasons for these two parts. Goals of the system. Examples of the uses of the systems.

II. CONCEPTUAL DESCRIPTION OF STRIPE 6

Efficiency. Techniques used to achieve efficiency: variable length records, field embedding, generalized record descriptor. System parameters. Character string packing. Structure of data: categories and descriptors. Hash code algorithm. Limitations of the system. Flexibility: enlarging files, adding fields, overlaying fields. Modularity.

III. FUNCTIONAL DESCRIPTION OF STRIPE 18

The data model, simplified and in detail. File descriptions. The execution model. Program descriptions.

IV. CONCEPTUAL DESCRIPTION OF SCRIPT 46

1. Hardware 46
2. Software - An Overview 47
3. Data Storage, message file, decision, tables, system parameters, in-core data 50
4. Ease of Use 54

V. FUNCTIONAL DESCRIPTION OF SCRIPT 58

Program units.

VI. EVALUATION 65

BIBLIOGRAPHY 69

Page

APPENDIX

A. PROOF THAT THE LINEAR QUOTIENT HASH ALGORITHM WILL PROBE ALL SLOTS OF A FILE IF THE DIVISOR IS PRIME. 70

B. SAMPLE SCRIPT LESSON IN LIMITS OF INFINITE SERIES 72

C. DESCRIPTION OF STRIPE APPLIED TO AN ACADEMIC RECORD SYSTEM . . 77

D. PROGRAM LISTINGS FOR STRIPE 83

E. PROGRAM LISTINGS FOR STRIPT 161

LIST OF TABLES

TABLE Page

1. Performance of Hash Algorithm 12

LIST OF ILLUSTRATIONS

FIGURE		Page
1.	Simplified diagram of the file system	20
2.	Category file illustration	27
3.	Descriptor file illustration	27
4.	Relationships of hardware and software units in SCRIPT	49
5.	Example of a state/action table, simplified	50
6.	State/action table with message vector	51
7.	SCRIPT decision table and message vector form	56
8.	SCRIPT message list form	57

A DATA RETRIEVAL SYSTEM WITH HIGH STORAGE EFFICIENCY AND A COMPUTER BASED INSTRUCTIONAL SYSTEM

CHAPTER I

INTRODUCTION

The motivation for this work stems from experience using a computer in a small college. Typically, one finds the following conditions. The computer is small, such as an IBM 1130 or an NCR 100. The use of the machine is divided between academic and administrative work. The administrative work is often hampered by the lack of sufficient memory. The academic work involves running programs in batch from some computer classes, a few math classes, a few natural science classes and a smattering of others. It does not seem economically feasible to have much, if any, online work through terminals. Most instructors feel they are too busy to learn how to use the machine. The few knowledgeable people running the computer center are too pressed for time to develop more efficient systems.

In this environment I was presented with a request to keep transcripts on file, which had been thought impractical on our size machine, an IBM 1130 with 8K by 16-bit core and a single disk holding about a million bytes. At the same time it was clear that more use of the computer should be made in instruction, but a simpler way to write the instructional modules must be found. Also, we needed to be able to teach more than one student at a time.

The foregoing led to the desire for two systems. One is an information storage and retrieval system generalized enough to allow it to be easily

installed for a wide variety of sets of data. The other is a generalized instructional system which would require little more of an instructor than the knowledge of his discipline.

Why should these be included in one package? First, because many small schools need both types of capabilities to justify having their computer. Second, because the hardware and many routines used in the instructional system lend themselves to remote access to the data retrieval system.

The goals for the information system are:

1. It should run on a computer with as little as 16K bytes of main memory and a single disk.

2. Storage should have at least 90% efficiency (defined in Chapter II).

3. Additions, deletions or modifications should be easily made at a rate of 1,000 per hour or more.

4. It should be easily adapted to differing formats of input.

5. It should have a query function in which selection and refinement of subsets of the data base can be made, sorting of the selected subset done, and listings in a variety of formats can be given.

6. The system should be expandable to handle extra disk drives.

7. It should be possible to add new fields to records without rebuilding the whole file.

8. The system should be relatively easy to transfer to a new computer.

The instructional system should meet these goals:

1. An instructor should be able to write a lesson easily - with no more than thirty minutes orientation to the system.

2. The system should be capable of original instruction or testing.

3. Feedback should be available to the instructor regarding the strength of the teaching module.

4. Up to eight terminals can be maintained in a time-sharing mode on a computer with 16K bytes of main memory.

5. The system should have an average response time of 3 seconds or less.

6. The cost in volume use should be around $1/hr. per terminal or less.

A search was made of existing systems that would at least approximately meet these goals. There was nothing available from IBM or known to CUETUG, an 1130 user's group. A very generalized information system, DRS, was available from Aeronautical Research Association of Princeton (now available from DNA, Inc.) which was very good. However, the storage efficiency was not great enough and a high volume of record modification was not practical. Another data storage system available from a government funded project and used by several 1130 installations also lacked in efficiency of storage, giving only about 50%. No good system for computer based instruction on the 1130 through terminals has existed. IBM has offered a communications capability on the 1130 but the cost was way beyond what would be possible for economical instruction. No version of Coursewriter or anything like it seems to exist for a machine of the size contemplated.

The information system developed is called STRIPE (System to Retrieve Information Packed Efficiently). The first version of STRIPE is now being used at Principia College. It has a storage efficiency of about 65%. The latest version has storage efficiency of up to 95%. Almost any kind of data may be held, integers, floating point numbers, or character strings. Execution times are good. The volume of data that can be handled is such that in an application such as at Principia (where cumulative academic records are kept) over 1,500 student records can be held in under a half million

bytes. (This means it can all fit on the standard single disk on an 1130.) The system can be stretched to accomodate up to 2,500 records on a single disk with degradation of execution. On a multi-disk system it could get up to 13-15000 records. These records include all course information, names, addresses, transfer credits, grade averages, and so forth. A complete evaluation of STRIPE is given in Chapter VI.

Using STRIPE the user may obtain typical reports such as class lists, grade reports, etc. in the above application. In addition he can interactively query the system to select subsets of the master records. For example, all the students with grade averages of 3.0 or better who are not living in dorms could be selected. Statistics, such as maximum, minimum, average, sum, and standard deviation can be requested. Selected subsets may be further refined by applying additional criteria to them. They may also be sorted on any fields and listed.

The instructional system is called SCRIPT. This is not an acronym - just somewhat descriptive of the way an instructor would write a lesson module. Simply put, the instructor writes a script containing information and questions he would give the student. The student's response determines the next part of the script to be given him.

SCRIPT is running and proven easy to use. A seventh grader and a college instructor have each written lesson modules after less than half an hour's instruction in the use of the system. Any subject matter can be taught if the teaching can be in the form of a dialogue with questions and answers. Teletypes or teletype compatible CRT's can be used. With a different interface other terminals may be used.

Both SCRIPT and STRIPE will be made available to users. STRIPE will be

put into the library of the College and University Eleven Thirty User's Group (CUETUG). It should be a valuable addition to the group's software resources. SCRIPT will be available to accompany the interface which makes the system possible. The interface was loaned by Logicon, Inc. The device takes input from the terminals and puts it into buffer storage locations in the 1130 memory via cycle stealing. The interface also provides interrupts on reception or transmission of terminate characters, reception of a 'break' signal, and detection of a disconnect or parity errors.

In this work many concepts have been explored and exploited. Various data structures for intra-and inter-record organizations such as inverted lists, singly and doubly linked lists, etc. have been used. Language design and interpretation techniques were implemented in the query language as well as in the instructional system. In the instructional system simple time-sharing was implemented. Garbage collection techniques had to be evaluated and implemented. Searching and sorting techniques including hash coding, "Shell sort," "Quick sort," and others were tested, improved, and used.

In addition attention was given to the overall system concept outside the computer. To a great extent the computer system is adaptable to the user's way of doing things. This is illustrated in adapting the existing format of input cards, in leading the user when putting data or commands in through the console, and in the ease with which an instructor can use SCRIPT.

CHAPTER II

CONCEPTUAL DESCRIPTION OF STRIPE

1. Efficiency

The measurement of storage efficiency is straight forward. The ratio M/U is used where M is the minimum space theoretically required for a record, and U is the space actually used. Two problems arise in applying this definition.

First, should the space used by a master file record include some prorated portion of auxiliary files such as index and parameter files? Only the space actually used in the master record will be counted here. This simplifies the evaluation and makes it possible to evaluate master files for which the supporting files are unknown as is the case in the comparisons made in the last chapter. Also, in typical systems the volume of data in the master file is so much greater than that in the auxiliary files that it would make only a trivial difference in the above ratio to include them.

The second problem lies in deciding which fields are necessary data required to complete the information, and which are overhead. This can be subjective, but the differences in the ratio will be small.

2. Techniques Used to Achieve Efficiency

Variable length records

The master file contains variable length records. This is desirable for data bases in which the record may need to contain more data as time passes. This means the record must start out with some initial size and increase in size as needed. The increase could be determined dynamically

or set as a fixed increment. In STRIPE a fixed increment is used, stored as a system parameter.

Since variable length records are used, an index to the master file must be used. This means a pointer system must be defined. In STRIPE storage is on disk, so the pointer will involve the sector and the word within the sector. Here a design decision must be made. It would be desirable to have pointers fit in one 16-bit word. How many bits should be used for the sector and for the word? If we use 12 bits for the sector then there can be up to $2^{12}-1 = 4095$ sectors. This leaves 4 bits for the word pointer. There are more than 16 words per sector, but if the word pointer is made to represent 20 word blocks it can reference up to 320 words. This fits in well with the IBM 1130 used in the project. The exact numbers can easily be changed to fit the specifications of a given computer. For a data base such as the one which started the project in which transcripts and other data are kept, about 2 records per sector would be possible. This would allow a file of up to 8190 records. Since this is designed for small schools, it should be adequate. Obviously, a change to a 2 word pointer could be made easily if necessary for a bigger file.

Generalized record descriptors

One source of waste in record storage is the allocation of space in records for fields that don't exist in some records. To allow each record to contain only the fields that actually are filled in, the following approach is used.

Records are considered in a generalized way as made up of four parts:

1. A mandatory block of fixed fields, present in all records.
2. An optional block of fixed fields which may or may not be present in

a record.

3. A variable field which may be of length zero. Several sub-fields may be included.

4. A block composed of zero or more groups of fixed fields.

These will be referred to as the mandatory block, optional block, variable field, and variable block.

More generalization could be introduced, but this seems to allow for any reasonable type of record without introducing too much overhead.

Field embedding

One of the biggest reasons for low storage efficiency in many information structures is the use of more bits than necessary to store a given datum. As an example in the extreme, it is not unusual to find a whole word used to indicate sex when one bit would do. To avoid this problem the following approach is used.

Each block is considered as a string of bits. Fields are embedded in the string, allocated just enough space for the values to be entered.

The result is that no field takes more space than needed. To keep track of this, a pointer system describing record layout is kept in the system. This is stored once in a parameter file so it does not introduce any significant overhead.

3. System Parameters

A system parameter file is maintained. In it are kept the above mentioned field bit pointers, sizes of various files, block sizes, a character conversion table, etc. This allows non-duplication of data as well as effectively providing communication between different units of the system.

4. Character String Packing

Character data is stored as a subfield in the variable field. The subfield is prefaced with one word which tells which subfield it is. Also, the number of 16-bit words used in the subfield is given. The data is stored 3 characters per word, allowing for 40 possible characters. A special routine from the IBM commercial subroutines is used. If more than 40 different characters are used then they would be stored 6 bits per character for up to 64 characters, 7 bits for up to 128 characters, etc.

5. Structure of the Data

Each record has a prime key. Using the hashing algorithm described below on this key, a record's entry in an index is accessed. The index, of course, points to the record. If necessary, the record may be found by a sequential search of the index for a hash of the name, if any, of the record.

Records may be in one or more of various categories defined for the data base. A file for these categories is maintained. Each category record contains a list of pointers to the master records in that category - an inverted list.

The groups that may be added to the fourth block of a record may have descriptors associated with them. A descriptor file is maintained. As with the categories, each descriptor includes an inverted list of pointers to the master records with groups associated with that descriptor. A descriptor might be a course description, parts description, etc.

6. Hash Code Algorithm

As mentioned above, hashing is used to access the master index. Hashing

is also used to access the descriptor file, though no index is needed since it can be arranged for the records to be of fixed length. It is also used in the garbage collection routine to keep track of the new addresses of the master records. The algorithm used is one of the best available, the linear quotient hash algorithm. A general description of it is given in (1). A comparison of it with other hash algorithms is given in (2).

The specific application of the algorithm here is as follows. To insert a new record or access an existing one, a sequence of pointers must be generated. Call them $p_0, p_1, \text{---} p_n$ where there are n records in the file. The p_0 record is examined. If it is available for insertion or is the record being sought, as appropriate, then it is used. If not, we call the situation a collision. In such a case the p_1 record is examined and so on until either an appropriate record is found or n records have been processed. In the latter case either there is no more room for insertion, or the record sought does not exist in the file. Justification for this follows.

The sequence (p_i) is generated using what we call the prime key, K, such as an identification number, and a divisor, D. D will be a prime number here, though it could be done otherwise. The quotient, Q, is computed as the integral part of K/D. If $Q \equiv \emptyset \bmod D$, Q is set to 1. With the preliminaries out of the way, (p_i) is defined recursively as:

$$p_0 = \text{remainder of } K/D + 1$$

or

$$= K - \lfloor K/D \rfloor * D + 1$$

$$p_{i+1} = (p_i + Q) \bmod D + 1$$

By the definition $p_i \leq D$. Essentially then, D is the size of the file. A result in number theory shows that all the integers 1,2,---,D will be included

in (p_i), i = 0,1,---,D-1. A sketch of the proof of this is given in the appendix.

Divisors other than prime numbers might out perform a prime number in some cases. Nonprimes might also probe each file slot if necessary for many sets of keys. But using a prime number for D guarantees saitsfactory performance regardless of the nature of the keys.

7. Performance of the Hash Routine

The performance of a hash routine depends partially on the nature of the keys used. The tests made on this one are on a set of 1,000 keys which are 6-digit student alpha numbers, ranging between 500000 and 999999. Eight hundred thirty eight were assigned by a registrar's clerk from an alpha table and 162 were artifically generated to fall between the existing ones in order to fill out the data set.

In Table 1, Load Factor is the percent of slots in the file used up. Data is gathered for entries from the three thirds of the data relative to the order in which they are entered. The average and maximum number of probes required to locate a record are given for each third as well as the overall figure. This can be compared to figures for the binary search technique in which 9 probes would be needed when the load factor is 50% and 10 probes required for higher loads.

The efficiency of this accessing technique begins to drop seriously at a 90% load with this data. An index file is being used in which each entry is only a few words. It does not use a significant amount of space to allow at least 10% more slots in the index file than we will have entries.

A formula for the best average number of probes needed to access an entry in a hash table is given by Morris (3).

It is

$$E = - \log(1-\alpha)/\alpha$$

where α is the load factor. For $\alpha = .8$ this gives $E \simeq 2.01$. The overall figure for $\alpha = .8$ in Table 1 is 2.14, which seems to be a reasonable approach to the optimum.

TABLE 1

PERFORMANCE OF HASH ALGORITHM

Load Factor	First Third		Second Third		Last Third		Overall	
	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.
50%	1.05	2	1.18	4	1.68	7	1.30	7
60%	1.06	3	1.49	6	2.21	8	1.55	8
70%	1.07	3	1.33	6	2.64	11	1.68	11
80%	1.09	4	1.62	7	3.82	21	2.14	21
90%	1.09	4	1.82	8	4.90	29	2.60	29
93%	1.09	4	2.37	11	6.41	32	3.29	32
95%	1.10	4	2.36	11	6.88	32	3.45	32

8. Logical and Physical Files

In order to use more than one disk for storage of the master records, there must be more than one physical file. STRIPE allows as many as five separate physical files making up the logical files. These files are given the symbolic numbers 1, 11, 21, 31, and 41. These numbers are specially chosen for the calculation of the right physical file when given the sector of the logical file.

The calculation of the proper physical file is done using as input the logical file sector and word block together with five values from the parameter

file. These give the number of sectors in each of the five possible physical files. The file number is built by starting with 1 and adding a multiple of 10 as indicated by comparing the logical sector to the parameters.

9. Limitations of the System

With the previously mentioned decision to use pointers consisting of a 12-bit sector pointer and a 4-bit pointer to the relative 20 word block within the sector there is a limitation of 4,095 sectors in the logical file. This would handle several thousand students in a typical student information system with 4 year transcripts included. If it were necessary to handle a larger file either word blocks of larger size - 40 or 80 words - would have to be used so that 13 or 14-bit sector pointers could be used, or 2-word pointers could be used. The latter would require additional space in pointer files such as the inverted lists kept in categories and descriptors. Straight forward programming changes would be necessary.

As presently written the system can be used with up to 5 disk drives. Assuming that peripheral files - index, descriptors, etc. - are kept on the disk which contains the operating system and all stored routines, the other drives would contain the master file. Advantages in speed would be found because less travel of the disk read/write arms would be necessary. Actually, the capacity of this system is only limited by the capacity of the hardware. It can use as many disk drives as can be run on the computer. On a 5-disk 1130 15,000 students can be handled.

10. Flexibility

There is great flexibility in types of data which can be stored. If records are virtually all character, the mandatory block may consist of very few fields, and the variable field will be large. We might have records

which consist of just the mandatory block if every record is fixed and numeric.

It is not unusual for the users of an information structure to find that their master file area has become full. They may have to totally rebuild their file. In STRIPE the procedure is easy. To understand the procedure involved as well as other aspects of the system to follow, we should first look at the parameter or communications file. During execution it is held in core.

For our purposes here we need to be aware of the following parameters.

NSLMF - the number of sectors in the logical master file

MFDIV - the divisor for the hash algorithm for the master file

NS1,NS11,NS21,---NS41 - the number of sectors in the physical files with symbolic numbers 1,11,21,31,41.

NWMB - number of words in the mandatory block

NWOB - number of words in the optional block

NWGP - number of words in the fixed groups in the variable block

NFMB - number of fields in the mandatory block

NFOB - number of fields in the optional block

NFGP - number of fields in each group in the variable block

BP1,BP2,---BPM - pointers to the bits at which the fields of the mandatory block, optional block, and variable field begin. (BP1 = 0)

GP1,GP2,---GPN - pointers to the bits within a group at which fields of the fixed groups in the variable block start. (GP1 = 0)

The parameter file includes many other quantities, some set at the time of generation of the system as are the above, and some dynamic, but the above are all that are needed for the moment.

Continuing with the problem of enlarging a full file, the first step is

to define new file space. If there has previously been 1 physical file for the master records it will have been symbolically represented as file 1. In this case the logical and physical file are the same. Now, the new file space will be an extension of the logical file. It will have symbolic number 11. The one logical file will be composed of two physical files. Whenever I/O on the logical file is to be performed the pointer to the location in the logical file is converted to a pointer into the physical files using calculations on the logical pointer and NS1,NS11,---NS41. (The system could easily handle more than five physical master files by including more of these parameters.) If we already had physical files 1 and 11, the new one would be 21.

The second step is to add file definition statements describing the new file space to all programs which reference the master file and recompile them.

Third, the parameter for the number of sectors in the physical files must be updated.

Fourth, the new file space must be initialized to identify it as free space. Then the system is ready. In terms of time it could all be done in half an hour or so. The new file space may be on the same disk as the old or on a disk on a different drive.

Sometimes after an information system has been in use for a while, it is found necessary to add new fields to the records. Again, with many systems a complete rebuilding is necessary. With STRIPE it is only necessary to update the parameters for number of words and fields in the various blocks and the field bit pointers, and then to run a program which moves the information in each record over to make space for the new field. This would involve a few minutes, human time, and a fairly small amount of machine time,

since most records will have some available space.

Fields may be defined but unused by simply allocating zero bits for the field. That is, we could have

- - -	BP7	BP8	BP9	BP10	- - -
	38	41	41	49	

for field bit pointers. This means that field 7 begins with bit 38, field 8 begins at bit 41, field 9 begins at bit 41, etc. Thus field 8 has no bits. If it is expected that in the future field 8 will be used, it should be taken into account at the time of generation. By this process the extra storage space will not be used until required.

A useful feature of this technique is the ability to overlay definition of fields. As an example, we might wish to add a group to a student's record representing a course he has enrolled in giving department number, course number, section, and date. When grades are given if it were not desired to keep the section code, the grade and course credit codes could be put in its place. The field bit pointers for a group might look like:

GP1	GP2	GP3	GP4	GP5	GP6	GP7	GP8
0	5	15	23	32	15	19	23

In this arrangement the department number begins with bit 0 and includes 5 bits. Course number begins at bit 5 and includes 10 bits, section at bit 15 with 8 bits, and date at bit 23 with 9 bits. The fifth field is a dummy representation to give the end of the fourth (date) field. The grade code, field 6 and the course credit, field 7, overlay the section. Field 8 is another dummy entry. Programs which were designed to operate on courses being taken currently would be able to refer to the section field while programs to enter the grade would refer to the grade and credit fields.

11. Modularity

STRIPE is modular in various ways. Input-output routines can be changed

to fit the needs of a particular application. The file accession algorithms are independent of the programs which add, delete, modify and retrieve records. Since the system is configured with parameters, the sizes of various files as well as the size and layout of master records can be changed without changing the programming.

CHAPTER III

FUNCTIONAL DESCRIPTION OF STRIPE

1. The Data Model

Simplified Model

First we look at a simplified picture of the model of the file system. Though this leaves out a host of details it should provide a good framework to fit the details into later.

STRIPE makes use of six permanently stored files which are essential to its operation. Another four files are used in an auxiliary status for the storage of standard messages, abbreviations, etc. In a given application there might be more or fewer of these auxiliary files. The six essential files are for: 1) master records, 2) category descriptions, 3) descriptions for the types of groups that might be appended to master records, 4) parameters for the system, 5) index entries for the master records, and 6) a working space file.

The master record has 4 parts as described in Chapter I, a mandatory fixed block, an optional fixed block, a variable field, and a block of zero or more fixed field groups. Each master record is identified by a key number. This could be a hash of an alpha field if an inherent identification number is not present.

It may be desirable to be able to categorize master records according to a given field contents. To this end the category file contains a name of the category and an inverted list of pointers to each master record in that

category. The maintaining of categories may be omitted by turning off a switch in the parameter file.

The descriptor file contains descriptions related to the groups of fixed fields which may be added to the end of the master records. For each descriptor an inverted list is kept of master records having that kind of group. Use of this file may also be turned off with a switch in the parameter file.

The parameter file carries a great variety of information such as the size of files, pointers to the beginning of the chain of free areas and the end-of-file free area, character tables and so forth. In the following examples only a few of the parameters are used. (See Figure 1.)

The work file is not used in the following example. It is used for temporary storage in garbage collection, selection of subsets of master records, etc.

This example starts with the parameter file. It tells us there are 6 records in the master file. The index has 7 slots. (The physical size may be 7 or more, but if the divisor used in the hash algorithm is 7, that will be the effective size.) The field in the master records used as the criterion for categories is field 4. The first of the chained free areas begins at address 40. The free area which goes to the physical end of file begins at address 65.

In this simplified model the addresses are in terms of word blocks. The free area beginning at block 40 is 7 blocks long as given in word 8. Word 9 points at the next free area at block 54. That free area is 6 blocks long and is the end of the chain since the pointer is Ø. The free area at block 65 is not chained. It extends to the end of the file and is pointed to by the parameter file. The first record has key = 103. Its entry in the index

Master File

Index

	Key	Pointer
1	105	15
2	113	31
3	97	60
4	115	47
5	0	0
6	103	1
7	111	20
8		

Address	Mandatory fixed 1	2	3	4	Optional fixed 5	6	7	8	Variable field 1	Groups 2	3	1	2	3
1	103			C2					D1			D3		
15	105			C4					D2					
20	111			C2					D1					
31	113			C1					D2			D3		
40	Word 8 = 7; word 9 = 54; other words = '$/'													
47	115			C3					D3					
54	Word 8 = 6; word 9 = Ø; other words = '$/'													
60	97			C2										
65	Word 8 = 32000; word 9 = 0; other words = '$/'													
:														

Parameter File

Number of master records	6
Size of index	7
Category field	4
Pointer to free area	40
Pointer to end-of-file free area	65

Descriptor File

Descriptor key		Inverted list				
D1		1	20	0	0	0
D2		15	31	0	0	0
D3		1	31	47	0	0
0		0	0	0	0	0

Category File

Category key		Inverted list			
C1		31	0	0	0
C2		1	20	60	0
C3		47	0	0	0
C4		15	0	0	0
C5		0	0	0	0

Figure 1. Simplified diagram of the file system.

file is in the sixth slot. We can calculate this as the proper slot by using the hash algorithm. Using a divisor of 7, the quotient $\frac{103}{7}$ = 14 with remainder of 5. The pointer should be 5+1 = 6. This record also has field 4 = C2. Checking the category file we see that category C2 has the pointer 1 in its inverted list. This master record also has a couple of groups of types D1 and D3. In the descriptor file we see that the inverted lists for D1 and D3 each have pointers to block 1. In the illustration each record is shown having all four parts for ease in labeling, but of course this is not necessarily the case. Each of these files would probably have more data in the records, such as names of categories, descriptor types, etc.

A detailed breakdown of the record contents on each file is presented next. Notice that in each case some data is system data while the bulk of it is relevant to the data base.

2. File Detail

As described above there are master, category, descriptor, parameter, index, and work files, as well as a standard message file which are basic to the system. In the sample system for a school registrar, described in the appendix, there are also files for department and letter grade symbols, names of school requirements, and descriptions of the school requirements. These special files are optional.

In the file descriptions the following terminology is used. A pointer to a record or free area in the master file is a 16-bit word of two parts, the relative sector and relative word block. The relative sector is the sector relative to the beginning of the logical file where the first sector is numbered 1. The relative word block is relative to the beginning of the sector. Block size is 20 words.

Master file

The master file, while logically one file, may be made up of from one to five physical parts. These are symbolically referred to as files 1,11,21,31 and 41, as explained earlier.

In succeeding sections there will be references made to field pointers and word pointers within records. These would be calculated when fields and blocks of master records must be accessed. There is a significant difference between the two types of pointers. The field pointer to a given field is always the same, even if some preceding fields do not happen to be present as would be the case for a field in the block of groups when the optional block is not present. On the other hand the word pointer to the beginning of the variable field, for instance, depends on the presence or absence of the optional block.

In a given record the layout for the group is repeated for as many groups as there are in the record. The field number of the ith field in the nth group would be:

NFMB+NFOB+1 + (n-1) * (no. of fields in group) + i

As an example the field number of descriptor key 3 in group 6 would be: (assuming 7 fields per group counting the dummy and 46 fields in the mandatory, optional, and variable fields blocks)

46 + (6-1) * 7 + 3 = 84

If the system were searching a record for some specific data in the 4th field of a group, it would start with field 50, then 57, 64, etc. until the last group was checked. Since the beginning of the mandatory block has the number of groups in the record, this can be done easily.

The storage efficiency of this scheme can be evaluated as follows. The first four fields of the mandatory block use up 30 bits. Each block ends on a

MASTER RECORD DETAIL

Field No.	Description	Bits**	Relative bit** pointer
	Begin Mandatory Fixed Block		
1	Record Status bit Ø : optional block bit 1 : variable field bit 2-6 : unused bit 7 : error	8	Ø
2	Length of variable field in words	7	8
3	Number of words in record	9	15
4	Number of groups of fields in block of groups	6	24
:	(Any more fields are application specific. Assume the rest are as in the sample in the appendix.)		
:	A real mode number	32	195
NFMB*	Unused (This contains the number of bits needed to make the block end on a word boundary.)	13	227 14 words
	Begin Optional Fixed Block		
NFMB+1		4	240
:			
:			
NFMB+NFOB	(Unused)	12	340 7 words
NFMB+NFOB+1	Variable Field (Each subfield begins with a header containing the subfield number in the first byte and the length in words of the subfield in the second.)	--	352
NFMB+NFOB	Begin Block of Groups		
+2	Descriptor key 1	6	Ø
+3	Descriptor key 2	10	6
+4	Descriptor key 3	8	16
:	(Data fields)	:	
:		:	
	Last data field in group	8	40
+NFGP	Dummy	Ø	48

*See abbreviations in Chapter II.
**These figures are examples for illustration only.

word boundary which means the expected number of spare bits is 8 (for 16-bit word machines) for the mandatory optional blocks. Each subfield in the variable field uses 16 bits of overhead. Also, since each is stored 3 characters per word there may be 0,5, or 10 bits wasted for an expected value of 5. Groups end on word boundaries, also. However, to avoid wasted space various ploys such as lumping groups into super groups can be used so that only a bit or two per group is wasted. The space used for a full record is given by:

$$S = (\text{Mandatory words} + \text{optional words} + \text{number of groups} * \frac{\text{words}}{\text{group}} + \text{variable field words}) * 16$$

The expected amount of waste space will be (assuming 2 bits per group):

$$W = 30 + 8 + 8 + (\text{number of subfields}) * 21 + \text{number of groups} * 2 + 16 * (\text{words per group})/2$$

The efficiency is

$$E = \frac{S-W}{S} = 1 - \frac{W}{S}$$

For the sample in the appendix the number of words in the mandatory block is 14. In the optional block there are 7 words. The variable field might have an average length of 30 words with 3 out of 4 possible subfields. Twenty-five groups of 3 words each might be present. Then

$$S = (14 + 7 + 25 * 3 + 30) * 16 = 2016$$

$$W = 30 + 8 + 8 + 3 * 21 + 25 * 2 + 16 * 3/2 = 183$$

$$E = 1 - \frac{183}{2016} = 91\%$$

Free Areas in the Master File.

There are two types of free areas, those left by the moving or deletion of records and the end-of-file free area. The e-o-f area extends from the end of the last record to the end of the logical file. The words of thi

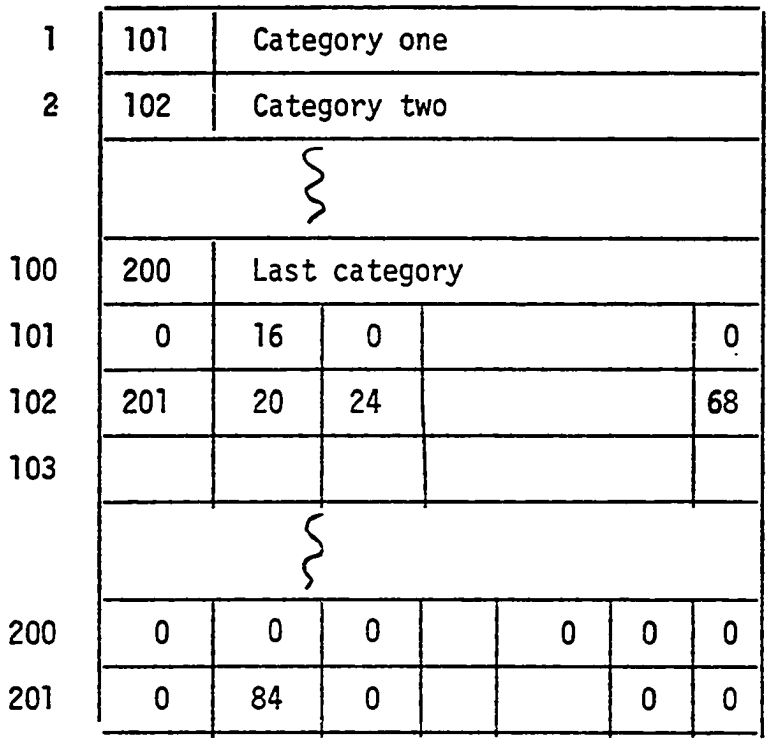
area are set to the EBCDIC code for '$/' except for the 8th and 9th words. Word 8 will be 32000 unless the size of the area is less than 32000 words. In that case word 8 gives the size of the area. Word 9 is Ø. The parameter file contains a pointer to the beginning of this area. The other free areas also are set to '$/' except for words 8 and 9 in each area. Word 8 will be the size in words of the free area. Word 9 will be a pointer to the next free area. End of the chain of free areas is signified by a zero pointer. The parameter file contains a pointer to the first free area as well as a pointer to the e-o-f free area.

Category File

The records in this file are in linked 12 word blocks. The first word of each block is the pointer to the next block, with zero being the end-of-chain. The first block contains the description of the category in words 2-11. The succeeding blocks contain the pointers to records in that category. The category number is the record number of the header block of a record. The headers are stored sequentially. (See Figure 2.) The parameter file has a pointer to the free blocks available. The parameter file also shows which field in a master record is to determine the category.

Descriptor File

This file is similar to the category file with the exception that a more complex header block is given, and the records are 32 words long. The data in the header block is packed bit-wise if it is numeric. Alphanumeric data may be packed 2 or 3 characters per word. The first word of the header is the identification number of the descriptor. This may be a hash of other fields, as in the sample. The second 16 bits is the pointer to the beginning of the inverted list. Two fields are used for the count of the number of



Note that category 002 has 2 blocks used in the inverted list.

Figure 2. Category file illustration.

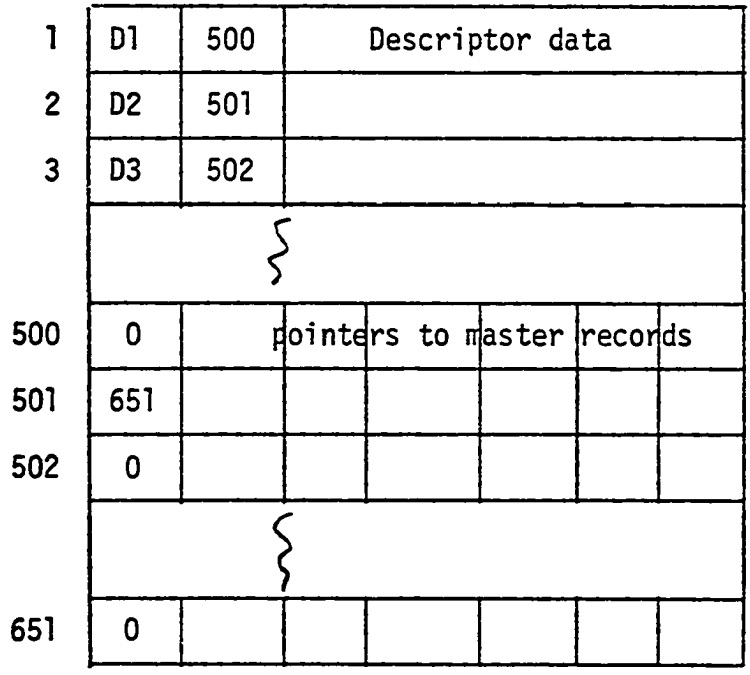


Figure 3. Descriptor file illustration.

records allowed with this descriptor, if applicable. The rest of the header is the descriptor data. The blocks for the inverted list are as in the category file. The parameter file points to the beginning of the free blocks so that when an inverted list needs more space it can be allocated.

Parameter File

A concise way to explain the parameter file is to list the fields in it. Each field is one 16-bit word.

Word	Description
1	Pointer to e-o-f free area, sector and word*
2	Pointer to first free area, sector and word*
3	Number of sectors in logical master file
4	Number records in master file
5	Master file garbage collection flag
6	Descriptor chain flag, 1 = off, 2 = on
7	Divisor for master file hash
8	Divisor for master move index (GARBG)
9	Sectors in file 1 (drive 0)
10	Sectors in file 11 (drive 1)
11	Sectors in file 21 (drive 2)
12	Sectors in file 31 (drive 3)
13	Sectors in file 41 (drive 4)
14	No. words in mandatory fixed block
15	No. words in optional fixed block
16	No. words in each group, variable block
17	Initial size of record in words (mult. 20)
18	Record increment when enlarged (mult. 20)
19	No. fields in mand. fixed block
20	No. fields in optional fixed block
21	No. fields in groups in variable block
22	Size in records of descriptor file
23	Descriptor file garbage collection flag

*Pointer format is used: bits Ø-11 for sector and 12-15 for word.

Word	Description
24	Divisor for descriptor file hash
25	Number in descriptor file
26	Number of categories (faculty)
27	Size of category file in records
28	Field in master record that holds category and serves as flag for category chains: on if pos., off if Ø or neg.
29	Number of possible subfields in variable field in master record
30	"Available" pointer for category file
31	Number of BA requirements
32	Number of BS requirements
33	Number of types of majors
34	Input device number
35	Output device number
36	Current date, qtr/year code
37	"Available" pointer for descriptor file
38	Number fields in descriptor records
39	Number words in descriptor records
40-50	Unused
51-79	Pointers to first bit of field for mandatory fixed block as shown in detail for master file, relative to beginning of record
80-96	Pointers for fields in optional fixed block
97	Pointer to bit at beginning of variable field
98-107	Pointers to bits at beginning of fields in groups in variable block, relative to beginning of group
108-125	Unused
126-165	Character table for use in A1A3, etc. (EBCDIC codes stored in A1 form)
166-200	Bit pointers for fields in descriptor records (not implemented yet)

Index File

The index file uses 5 words per record.

Words 1-3: key fields in records

Word 4: pointer to master record

Word 5: hash code composed from name field of master record
(The name is presumably first subfield in variable field.)

The divisor used in the hash algorithm determines the effective size of the index. For systems with 320 words per disk sector, there will be 64 records per sector. STRIPE uses prime numbers for the divisors and sectors might as well be used as fully as possible. Therefore, the divisor should be chosen to be the largest prime less than 64 times the number of sectors to be used. For example, if we need about 1000 index entries we might as well allocate 16 sectors, giving 1024 records. Then we will use a divisor of 1021, giving that number of effective records.

System Message File

A set of 20 character messages used to briefly identify errors, give system information, direct user actions, etc.

Working Space File

Disk space is provided for temporary storage used in garbage collection, selection of subsets of the master records, etc.

Any other files are special purpose. Those used in the sample system shown in the appendix are explained here since similar files would be likely to exist in many applications.

Requirements File

In the sample application a student academic data base is kept. There are requirements for graduation such as the number of foreign language credits, and number of upper level courses. This file holds a description of these school requirements for both the B.A. and B.S. degrees.

The records are fixed, 60 words per record. The B.A. requirements start at record 1, the B.S. at record 21. The number of different requirements for

a B.A. and for a B.S. degree is in the parameter file. Each record is a string of up to 60 numbers. These describe a matrix. The string of numbers is of the form

$$IR,\ IC,\ N_1,\ C_{1,1},\ C_{2,1},\ldots C_{IR,1},\ N_2,\ C_{1,2},\ C_{2,2},\ldots C_{IR,2},\ldots N_{IC},$$
$$C_{1,IC},\ C_{2,IC},\ldots C_{IR,IC}.$$

IR and IC give the number of rows and columns. Thus, the form of the matrix is:

IR X IC	N_1	N_2 - - - - -	N_{IC}
	$C_{1,1}$	$C_{1,2}$	$C_{1,IC}$
	$C_{2,1}$	$C_{2,2}$	$C_{2,IC}$
	:	:	:
	:	:	:
	$C_{IR,1}$	$C_{IR,2}$	$C_{IR,IC}$

The C_{ij}'s are department and course numbers of courses which satisfy the requirement. The N_j at the head of the column tells how many of the courses in the column are needed to satisfy the requirement. The requirement may be satisfied, then, by finding at least one column, j, such that there are N_j courses in the master record which match the department and course of an entry in that column. The C_{ij}'s are of the form +ddccc where dd is a department number, $0 \leq dd \leq 31$, and ccc is a course number, $0 \leq ccc \leq 767$. If an entry is of the form dd999 then any course from department dd will do. This eliminates the bother of long lists of courses. If all but a few courses in department dd will do, we can have entries of the form -ddccc, meaning this particular course must not be used in satisfying the requirement. The dd999 following would then accept all other courses.

This technique would seem to be a useful one to use in many cases where

records must be evaluated.

Requirement Title File

For output purposes, a file of titles of the requirements is kept.

Department Abbreviations and Grade Symbols File

This file has as its ith entry the letter designation of department i. Also, the letters used in grade symbols are kept.

3. The Execution Model

The process of defining the files, determining system parameters, and initializing the files is described in the appendix. For the present we assume the preliminaries to be done.

Access to the system is through an executive program EXEC. Its purpose is to bring the system parameters into common core storage shared by all program units, to determine from the user what function he wants, and to link to that function. The common area of core is labelled as follows:

COMM - an array (165) containing the system parameters.

FLPTR - an array (4) used in passing pointers such as sector and word pointers for reading records or word and bit pointers needed to access fields in master records.

STURC - an array (340) used to hold the current master record being accessed.

IERFL - a word used as an error flag on return from various subroutines

BUFF - an array of length 41 or more used to pass data from subprograms, such as those for reading cards, to main programs. (In main program QUERY, this array is replaced by several scalars and arrays peculiar to the inquiry process.)

There are other elements in COMMON in certain special programs, but the

above is always at the beginning of COMMON.

EXEC links to the following basic system programs as well as other special purpose programs satisfying needs of a specific application.

ADCAT adds a new category. If the system parameters call for the maintaining of categories of master records, this unit must be executed before master records are added.

ADDSC adds a new descriptor for the groups that could be added to the variable block at the end of the master records. If the system parameter calls for the maintaining of lists of records with given descriptor groups, this must be run before any such descriptor groups are added to records.

In both ADCAT and ADDSC an initial block of space for inverted files is chained to the record. Subsequently, the inverted list is maintained by the subroutine INVRT. The inverted lists contain the sector/word pointers to records.

ADMAS adds a record to the master file. Only the mandatory block and variable subfield 1 is set up. The steps are:

1. Read from the category file the category numbers on file.

2. Make sure there is space in the master file for a record.

3. Call RMASC, a routine which reads master record cards and puts the information into BUFF. (RMASC is a routine local to an application.)

4. If RMASC indicates the end-of-data the program writes COMM back into disk storage and links back to EXEC. Otherwise go on to step 5.

5. HSHF1 finds an index entry. If the key is a duplicate go to 3. Save the index pointer.

6. Next the chained free areas, pointed to by parameter 2 of COMM, are examined until a free area big enough for a record is found. If one is found greater than or equal to the standard initial length, but too small for two

records, the whole area is used for the new record. If no chained area exists or is big enough, then the record is put into the end of file area pointed to by COMM(1), which is the pointer to the e-o-f free area.

7. If COMM(28) is positive its value is taken as the field in the master record which determines the category. The pointer to the record is entered into that category's inverted list by subroutine INVRT. If COMM(28) is zero go on to step 8. If INVRT indicates an error such as no room in the category's list or nonexistent category, ignore this record and go to step 3.

8. The fields of the master record are packed from BUFF into STURC by routine IPFLD. Only the mandatory block is filled in.

9. The first subfield - probably a name - is put into STURC.

10. Housekeeping details are filled in, such as length of variable field, and zeroing out unused parts of the record.

11. Put the index entry in. Increase the count of the number of master records.

12. Write the record into the master file using routine WMASR.

13. Update the free area pointers.

14. Repeat from step 3.

ADVBL adds groups to the variable block at the end of the records. The steps of the program are:

1. The routine RVBLC is called to return a prime key, or identification number, of a master record together with a group of fields to be appended to the record. (RVBLC is a local routine.)

2. If RVBLC indicates end-of-data the last master record accessed, if any, is returned to storage. Then the parameter file is returned to disk storage and a link to EXEC is executed.

3. On the first call to RVBLC the record corresponding to the prime

key is brought into core by routine RMASR.

4. On succeeding calls to RVBLC, if the key is different from the one returned on the last call, the last record is returned to disk storage, then the record for the new key is brought into core by RMASR.

5. Check the physical length against the active length of the record. If there is not enough space in the record for a new group, the routine RECMV is called. (It will move the record to the end-of-file area, enlarge it, update parameters and pointers, and return to the calling program.)

6. The field number for the first field of the group is calculated.

7. If the parameter file indicates that descriptor inverted lists are to be maintained this is done by calling HSHF1 to access the descriptor and INVRT to add the record pointer to the list.

8. If all this has worked without error, the group is added to the in-core record. Then go back to step 1.

GPDRP deletes a group from the variable block of a record. This program operates as follows:

1. The descriptor file hash keys are read into an index in core. The field pointer to the beginning of the variable block of groups is calculated.

2. A card is read giving the key of a master record and the basic key of a descriptor. If end-of-data is encountered a link back to EXEC is performed. (Alternatively, there might be a card with a master key followed by cards with descriptor keys indicating groups to be dropped.)

3. The master record is accessed through HSHF2. The number of groups in that record is found and used to determine the field number of the last group.

4. The descriptor key of the record is examined. If it does not match the card data the group drops back by one group. If there is another group to

be checked, repeat this step. If there are no more groups an error message is given and control goes back to step 2. Go to step 5 if there is a match.

5. If the groups being dropped represent something like courses in a student record a date field in the group may be checked to be sure it matches the current date in the parameter file, since a normal drop of a course in a previous quarter would not be allowed.

6. The number of groups is decreased by one. The groups are repacked, wiping out the dropped group. The record is returned to the disk file.

7. If the parameter file indicates that descriptor lists are being kept, then the count is reduced by one in the descriptor record and the pointer to the master record is zeroed out of the descriptor's inverted list.

8. Go back to step 2.

DROP deletes a record from the master file.

1. A card is read with the key of a master record. If end-of-data is encountered a link to EXEC is performed.

2. The master record is accessed through HSHF2. The pointer to that record is saved for returning the area to the free chain.

3. The index file entry is emptied. The pointer word of the entry is set negative rather than zero. This is necessary to keep the continuity of the collision chains in the hash table.

4. If the parameter file indicates that categories of master records are maintained, this record's pointer is replaced by a zero in the category's inverted list.

5. If the parameter file indicates that descriptor lists are kept, then each group in the record is examined and its entry in the associated descriptor list is zeroed.

6. Finally, the record area is entered into the free area chain. The record length is saved. The record area is filled with '$/'. The length of the area is put into word 8. The current parameter file pointer to the free chain is put into word 9. The pointer to this area is put into the parameter file. The newly formed free area is written into the disk file. Go back to step 1.

GARBG compresses the master file so that all free areas are combined into one end-of-file free area.

1. A temporary file for storing an index to the changes in addresses is initialized. A core array to be used for pointers to the free areas is initialized.

2. Pointers to the free areas, including the end-of-file area, are put into the core array. A count of the number of free areas is kept.

3. The array of free area pointers is sorted into ascending order. The moving up of records starts at the first free area.

4. The pointer to the master record following this free area is calculated. The record is read and then written at the beginning of the free area.

5. An entry in the move index is made using hash coding on the old pointer. Both the old pointer and the new one are entered.

6. A new free area pointer is calculated. The pointer to the next master record is calculated. A check is made to see if that pointer is up to the next free area. If so, the pointer to the next master record is recalculated.

7. Each time another free area is "passed" in packing the file the count of free areas is decreased. When it reaches zero the end-of-file free area has been reached.

8. The parameter file entries pointing to free areas are updated. The end-of-file free area is initialized.

9. The pointers in the inverted lists of categories and descriptors are updated using the hash function on the move index file. The master record index is similarly updated.

10. The parameter file is returned to disk and a link to EXEC is performed.

QUERY allows four operations of inquiry into the master file. The first operation is selection of a subset of the master file by using the command SELECT. Pointers to the selected records are stored in a disk file working set. Selections may be made by specifying a criterion expression whose BNF description is as follows:

<crit exp> : = <crit> | <crit>AND<crit exp> | <crit>OR<crit exp>

<crit> : = <field><relation><value exp> | NOT <crit>

<field> : = F<num>

<num> : = a string of digits

<relation> : = LT | LE | EQ | GE | FT | EX

<value exp> : = a numeric value | <field exp> | '<string>'

<string> : = any characters

<field exp> : = <field> | (<field><op><field>) | (<field><op><num>)
| (<num><op><field>) | <num>

<op> : = + | - | * | /

The meaning of the above relations are mostly obvious. EX means that the given field exists.

The important semantics have to do with determing the operands of NOT, AND, and OR. The order of operation is strictly right to left. This means that the left operand of the verbs AND and OR is the criterion immediately to

the left of the verb. (There is no left operand for NOT.) The right hand operand for any of these verbs is the result of the entire expression to the right of the verb. Of course, the value of any criterion such as F10 LT250 is either 1 or 0. Blanks embedded within the three elements of the expression are not allowed. Blanks between them are permissible.

The right to left order is used for two reasons. First, the programming is greatly simplified since a priority table does not have to be consulted and stacking of operands is avoided. Second, the user of STRIPE is apt to be unfamiliar with conventions of priority with respect to Boolean operators. With this arrangement only one idea must be understood.

Refinement of a selection can be made by using the command REFINE and giving criteria as described above. After a selection or refinement the number of records selected is given on the console.

The selected set can be sorted into ascending order by using the command ARRANGE. Fields are specified as in the selection: F<num>. The fields may or may not be separated with commas or blanks. Up to 10 sort fields may be specified. The sort significance goes from left to right. The result of this command is a working set of pointers sorted into the desired order.

The currently selected records may be listed on the printer specified in the parameter file by using the command LIST. The whole record may be listed by specifying ALL. Specific fields of the record may be listed by specifying up to 10 numeric fields (to be locally implemented).

The last function in QUERY is to give some simple statistics concerning fields of the selected records by using the command, STATS. One, two or three fields may be specified. For each one the sum, average, standard deviation, maximum and minimum is given.

One other command is used, EXIT. It performs a link back to EXEC.

The specific steps in executing LIST, STATS or EXIT are relatively trivial and will be passed over here. Execution of REFINE is virtually the same as SELECT except that only records already in the working set are examined. Therefore, the attention is on the more interesting aspects of SELECT and ARRANGE.

SLECT

The program which performs the SELECT command is called SLECT. For space reasons SLECT is a main program linked to by QUERY. Its first job is to process the input of selection criteria. As an example of a criterion we could have

F1OLT (F16 - F11) AND F5 GE 235.6

In this criterion expression there are two criteria and a Boolean verb. SLECT will find the first criterion, F1OLT(F16-F11). A coded version of it will be placed in an array, CRIT, which is in common core storage. The coded version contains the field number, the relationship, the type of value, and a pointer to the value array where that value is stored. The criterion is coded into one word as follows:

Bits	Description
0-5	Field number
6-8	Relation
9-10	Type of value
11-15	Pointer into value array

The codes for relations are:

Code	Relation
1	Less than: LT
2	Less or equal : LE

Code	Relation
3	Equal : EQ
4	Greater or equal : GE
5	Greater than : GT
6	Exists : EX

The codes for value types are:

Code	Type
0	Integer number
1	Real mode number
2	Field expression
3	String

The pointer to the value array gives the position in an array, IVAL, or equivalently, VAL*, in which the actual numeric value, string value or field expression is stored.

In storing values all numeric values are stored in VAL in real mode. The pointer will be to the equivalent location in IVAL. String values will be stored in IVAL. The first location for the string will contain the length of the string. Field expressions will always be stored as a sequence of pairs: (operation, field) or (operation, number). The first field or number in the expression is assumed to have a + applied to it unless a - is used. By this means of storage evaluation can be done by "accumulator" technique. An accumulator is initialized to Ø. The first value is added or subtracted. The succeeding (op, val) pairs indicate an operation to be performed with the accumulator as the first operand and the value as the second. The result, of course, is left in the accumulator. The operation codes are 1, 2, 3, or 4 for add, subtract, multiply, or divide. A negative operation

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*By use of EQUIVALENCE, VAL and IVAL occupy the same space.

code means the following element is a number rather than a field. When this field expression is evaluated it will be strictly left-to-right.

Now, back to the main stream of interpreting the criterion. In the above example

F10LT (F16-F11)

would be coded into CRIT with the code for F16-F11 being entered into IVAL. A pointer to this entry in CRIT would be placed in an expression array XP. Then the AND would be detected. A numeric code for this would be placed in XP, following the pointer to the first criterion in CRIT. To distinguish between criteria pointers and Boolean codes, the Boolean verbs are coded as negative numbers. The codes are:

Code	Verb
0	(
-1	)
-2	AND
-3	OR
-4	NOT

(Parenthesized Boolean expressions are allowed.) Next in the example the criterion F5 GE 235.6 is entered in CRIT with the value 235.6 in VAL. The pointer to CRIT is entered in XP.

When it is determined that there are no more criteria, a right parenthesis (code,-1) is placed at the end of the coded expression in XP. (A left parenthesis was initially placed at the beginning.) Now the expression must be sorted into an appropriate order for execution. The order chosen for evaluating the Boolean expression is strictly right-to-left.

The sorting process is as follows. The array XP, containing the coded Boolean expression, such as

Symbols (Crit(1) AND Crit(2))

Code 0 1 -2 2 -1

is scanned to find the point where the left parenthesis is balanced, in the above case at the fifth element. Subroutine POLST is called which sorts the elements between the parentheses so that positive numbers (which are operands, or criteria pointers) come first from left-to-right in their same relative order, followed by the negative numbers in reversed order. Then the outer parentheses are erased by replacing them with -99's. The above would become

-99,1,2,-2,-99

In this process parenthesized inner groups are left intact and treated as a single criterion, being sorted as are the single positive numbers.

e.g. 0,1,-2,0,2,-3,3,-1,-1

becomes

-99,1,0,2,-3,3,-1,-2,-99

POLST would be called again and this example would become

-99,1,-99,2,3,-3,-99,-2,-99

The -99's will be ignored, so this is equivalent to

1,2,3,-3,-2

The meaning of this is:

R = Criterion 2 OR Criterion 3 (2,3,-3)

LV = Criterion 1 AND R (1,R,-2)

LV would be the resultant value, assuming that the criteria 1,2,3 all are evaluated to 0 or 1.

This process of repeatedly using POLST on XP until all parentheses have been resolved sorts XP into a reverse Polish string compatible with the strict right-to-left order of operations.

Finally, in the selection process the criteria must be evaluated against

a specific record. If the resultant value is one, the pointer to the record is saved in the working set. In evaluating a specific criterion as coded in CRIT, a function IRLVL is called. The process consists of making a copy of XP. This copy is gradually reduced until finally there is just a 0 or 1 left.

The process of placing or retrieving pointers in the working set is done through a subroutine IRTRV. This routine has internal buffers in which are images of blocks of the working set. This reduces the time needed in accessing the disk. Without the buffers the disk arm would be moving constantly between the master file and the work file.

ARRNG

Called as a subroutine from QUERY, it is the name of the program which performs the ARRANGE command. ARRNG first determines which fields are to be used as sort criteria. The fields are specified by the Fxxx form shown previously. As many fields as can be given with 20 characters may be specified. The fields may be run together or separated by blanks or commas. The fields are taken to be given in left-to-right order of significance. Then the actual sorting algorithm is entered to examine the records pointed at by the work set and rearrange the pointers into the desired order.

The choice of algorithm for this sorting is critical. There is no way to anticipate any inherent order already existing. Since the number of records to be sorted may be quite large, it cannot be done in core, even as a key sort. Bringing the necessary keys into the working set along with the pointers was rejected since to allow space for up to 10 keys in the working set would be costly in space used. To bring in one key at a time and do a separate sort on each in a radix sorting process would be prohibitively

time consuming for cases with several keys. Clearly an algorithm which allows the use of multiple keys and minimizes comparisons must be used. The two tried first are the "Shell" sort, or diminishing increment algorithm and the "Quicksort," or partition exchange algorithm (Knuth (7)).

As an example of the Shell process, a sort of 100 items took twenty minutes with increments of 63,31,15,7,3,1 and accessing the working set one pointer at a time. With a small buffer in the accessing of the working set this dropped to fifteen minutes. Changing the increments to 40,13,4,1 brought the time down to 10.5 minutes due to making two fewer passes. Drastically increasing the size of the buffer used in accessing the working set reduced the time to five minutes.

The same set of items was sorted using the "Quicksort" algorithm. The time was virtually the same. It became clear that while Quicksort required fewer interchanges it was making more accesses of the master records. The saving of time on the one hand was cancelled out on the other.

More effort on reducing the number of accesses of the master records is needed. Since the primary goal of this project was to improve storage efficiency, the improvement of the sorting algorithm will be deferred. The currently used methods seem to be a reasonable compromise between speed and storage space. All other methods would require significantly more space (except a "bubble" sort which wouldn't be considered).

MODRC

This program allows modification of master records in batches. Any of the four general parts of a given record may be changed. If the change involves expanding the size of the record, it may be moved. A code is initially given for each record to indicate which part of the record is to be

changed. This code is provided by the locally written routine, RDMDC, which reads the modification card.

UTLTY

A variety of subroutines are available to UTLTY for investigating all of the files in the system. They can list and/or patch any part of any file. This is used primarily for debugging purposes. However, it may also be used for data listings.

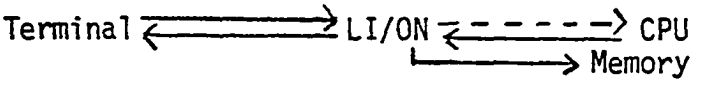
CHAPTER IV

CONCEPTUAL DESCRIPTION OF SCRIPT

1. Hardware

The hardware used for SCRIPT consists of the IBM 1130 with 16K bytes of core memory and single disk, a Logicon I/O Network (LI/ON) which allows direct access to main memory via cycle stealing, and one or more terminals. Teletypes were used. However, almost any type of terminal could be used with a different interface.

The relationship of the hardware is very simple as shown in this diagram.



The terminal communicates directly with the LI/ON interface when its line adapter is input-enabled. The LI/ON in turn puts the character received directly into a buffer in core reserved for that line. On receipt of certain special characters, such as BREAK or LINE FEED, an interrupt is issued to the CPU (indicated by the dashed line). At that point software takes over.

The CPU can send characters to the LI/ON and thence to a terminal when that terminal's line is output-enabled. Upon transmission of an end-of-transmission code, the LI/ON issues an interrupt to the CPU.

The buffers associated with each line are used for both input and output. By analyzing the characters input from the terminal, putting the appropriate response characters in the buffer, and synchronizing these actions through the interrupt system, SCRIPT can communicate with the user at the terminal.

2. Software - An Overview

The beginning of the chain of programs which comprise the SCRIPT system is the interrupt level subroutine, ILSØ3. Upon occurrence of the level interrupt associated with the LI/ON a hardware generated branch is executed to ILSØ3. When that routine determines that the interrupt came from the LI/ON it branches to a multiple use routine, LMCC. LMCC contains routines of a utility nature such as initiating read or write to a given terminal, test whether a line is busy, mask and unmask interrupts, etc. LMCC also contains the routine to respond to the interrupts.

ILSØ3 and LMCC were provided by LOGICON. They were modified some what for this sytem.

When LMCC has determined the cause of the interrupt it branches to USER, passing the interrupt data along. USER puts the interrupt data into a common area where it can be available for the FORTRAN programs. This data includes the number of the terminal causing the interrupt, the cause of the interrupt, and the character count (if applicable). USER then branches to the routines BREAK and TERM to set the interrupt flags.

The main routine servicing the interrupts is SERV, which services interrupts due to the reception or transmission of an end-of-transmission character (EOT). If the EOT character came on a transmission, SERV responds by either setting up another message to the terminal if certain indicators warrant it or setting up a return to the main program. If the interrupt occurs on reception of characters from the terminal, the characters are analyzed and appropriate action is taken such as calling MODUL to send a response to the terminal.

The function of the main program is primarily to poll the terminals. In turn each terminal is scanned by checking a word in its assigned partition to see if it is active. If not, a routine is called to see if the terminal

has been turned on. If it has, an appropriate message is sent, the partition is set to indicate it is active and the line is left in receive mode.

The LI/ON has a clock that counts each three seconds. This can be read by the program. At the start of each cycle of polling the clock is read. For each active terminal the time since the last communication with that terminal is checked. If it is too long a warning message is sent. If the terminal still doesn't respond after a reasonable time, it is hung up.

Figure 4 illustrates some of the relationships of the hardware and the various elements of the software.

The dashed lines between the LI/ON and the CPU indicates the interrupt signal. The dotted line to ILSØ3 signifies the hardware generated branch to the interrupt level subroutine when the LI/ON has issued the interrupt. The wavy lines indicate the sending of messages to terminals via the LI/ON.

An explanation of the process by which the program units can determine the appropriate response to input from the terminal requires an explanation of the data structure. Thus, the next topic should be the structure of the data storage.

3. Data Storage

There are four files of primary concern to the operation of SCRIPT. The first is the message file. All messages for all lesson modules are stored here. They can be referenced by their sequential record number. The second is the file of decision tables. These provide the logic governing the responses to inputs from the terminals. A full description is given below. The third file is an index to the modules in the system. The last is a system parameter file.

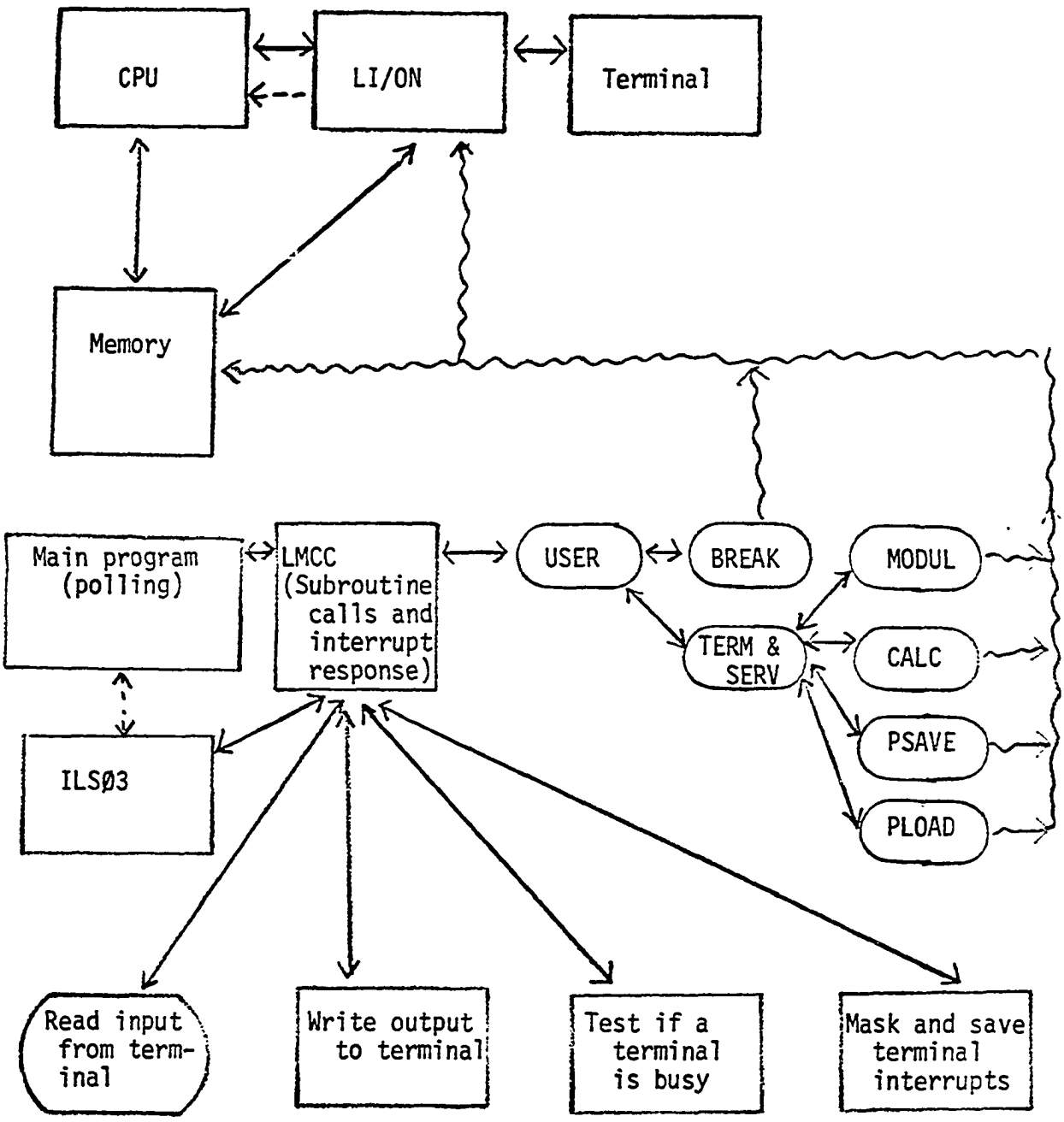


Figure 4. Relationships of hardware and software units in SCRIPT.

Message file

When a lesson is added to the system the set of messages is stored. During execution of a module these can be retrieved and sent to terminals as directed by the logic of the module's decision table.

The messages are stored in a form such that they are ready for immediate transmission to a terminal as soon as they are transferred to the buffer for that terminal. This means that the characters have been converted to the appropriate code for the terminal, such as ASCII for teletypes. Also, they have been packed two characters per word, put into the order required by the hardware, and had characters for line feed, carriage return and EOT added.

The program unit which accesses and transmits these messages is MODUL - discussed later.

Decision tables

A decision table (or state/action table) uses a current state (initially 1) and an input to determine the current action (message to be transmitted) and the next state.

Input State	1	2	3
1	NS = 2 MESS = 1,5	NS = 2 MESS = 6,8,2	NS = 1 MESS = 7
2	NS = 1 MESS = 3	NS = 3 MESS = 2,9	NS = 3 MESS = 4

Figure 5. Example of a state/action table, simplified.

In this example, with an initial state of 1, an input of 1 would cause messages 1 and 5 to be transmitted, and the next state would be 2. An input of 2 would then bring up messages 2 and 9, and the next state would be 3, and so on.

The actual storage of the decision tables is in two parts. There is a set of pointers to messages which is called a message vector, and there is the decision table itself. The preceding example would have the form:

Message Vector

Position	1	2	3	4	5	6	7	8	9	10	11	12	13
Message pointer	1	5	6	8	2	7	3	2	9	4	12	11	10

Decision Table

Input	1	2	3
1	2,2,1	2,3,3	1,1,6
2	1,1,7	3,2,8	3,1,10
H	1,1,11	2,1,12	3,1,13

NS,NCM,VPTR

Figure 6. State/action table with message vector.

The entries in the table are of the form (NS,NCM,VPTR). NS = next state. NCM - number of consecutive messages. VPTR = pointer to the position in the message vector where the pointer to the first message is found. If NCM > 1, then the next message pointer is in position VPTR + 1 and so on. In the

example, if the state = 2 and input = 1, then the next state will be 2; there will be 3 messages transmitted; and the first message pointer is in position 3 of the message vector. We see that messages 6, 8, and 2 should be sent.

The bottom line of the table is labeled H. It enables the student to receive help during the lesson. If he types $H the action indicated in this entry will be used. The state remains the same.

If there are n rows in the table for a lesson, the student will be able to respond with answers 1 through n-1. Other digits will be rejected.

The three components of each entry in the table are packed into one word. The numbers of bits allocated to each are such that

$$0 \leq NS \leq 31, \qquad 0 \leq NCM \leq 7, \qquad 0 \leq VPTR \leq 127$$

The message vector and the table are stored as one long string of numbers. The message vector goes first so that the values in VPTR will be minimized. As it is the message vector may not be pointed at with VPTR > 127. The message vector could be as long as 134 positions since VPTR = 127 and NCM = 7 would be permissible.

Index file

To access a particular module the position in the message file where its messages start and the position in the decision table file where its message vector and table begin must be known. This is kept in the index file. Also the length of the message vector, and the number of rows and columns in the table are kept. The entry for the module with identification i is kept in record i.

System parameters

The primary system parameters are:

1. The time increment used to determine when a non-responding terminal should be warned or cut off.

2. Number of entries in the index.

3. Pointer to the end of the decision table file.

4. Pointer to the end of the message file.

5. Physical size of the decision table file.

6. Physical size of the message file.

These items allow new lessons to be added and terminals to be controlled. This data is kept in a file on disk.

In-core data

The other part of the data structure is the main memory allocated to each terminal. The input/output buffer for each line already has been referred to. From the viewpoint of the LI/ON the first word of each buffer is that one with the lowest address. The first word is used by the hardware to indicate a character count and for flags indicating the status of the terminal. Each terminal also is allocated an area of core that is referred to as a terminal partition. It is a small allocation of 15 words. Here the data describing the current status of the terminal is found. The information consists of:

1. Bit flags to indicate active or inactive, teach or calculate mode, or whether a time warning has been given.

2. The time limit for next communication.

3. The number of messages that should be sent to the terminal.

4. The pointer to the next position in the message vector.

5. A pointer to the beginning of the decision table for this terminal.

6. A pointer to the beginning of the messages on disk for this module.

7. The current state in the lesson for this terminal (as applied to the decision table).

The eight other words are reserved to meet future needs of the instructor.

4. Ease of Use

As mentioned in the introduction SCRIPT can be used with great ease. The forms in Figures 7 and 8 may be used. The three parts of the forms are: 1) the decision table, 2) the message vector, and 3) the list of messages.

The decision table contains the logic which enables the system to determine what messages to transmit after a given input. The rows of the table correspond to the inputs. The columns correspond to states. Each entry in the table will specify the next state in the lesson which the user will be in. Each entry in the table also contains message information in two parameters. One is the number of consecutive messages to be sent. The other is a pointer into the message vector where the actual message numbers are kept.

The reason for this arrangement for indicating messages is to enable the decision table to be composed of single word entries.

To write a lesson for SCRIPT the instructor creates a script, or a series of groups of messages. Each group of messages should include a question requiring a multiple choice response. The individual messages are numbered in the message list. For each group of n messages to be sent a string of n consecutive message numbers is entered in the message vector. The decision table is filled in by indicating for each state and input what the next state (NS) should be, how many consecutive messages (NCM) should be sent, and where in the message vector those message pointers start (VPTR).

The initial state must be noted. The initial state of the lesson is 1. All the entries for state 1 should indicate the initial messages to be sent. (See appendix B for examples.)

The use of the last row of the table is special. This means that for normal input the choices should be from 1 to at most 8. The table should have one more row than the largest number of possible inputs in any one question. (Of course, the number of columns is the number of states.) The bottom row is used for extra help. In any state the entry in the bottom row should give help messages to be given to the student when he types $H.

As an example, look at the illustration in Figures 7 and 8. The initial state of 1 has entries for inputs 1 and 2 of (2,2,1) for (NS,NCM,VPTR). Only inputs of 1 or 2 should be made. (The system will reject 3-9.) For either input there will be 2 messages sent, starting with the number one entry in the message vector. The message vector shows that the messages to be sent are 1 and 2. From the message list they are:

"ZWEI UND ZWEI IST FUNF, NICHT WAHR?

1)JA 2) NEIN"

If the student types $H he will remain in the same state and get the single message

"NO HELP NEEDED".

However, when he responds say, 1, meaning JA, the table entry is (3,1,3). The single message has its pointer at position 3 in the message vector. That gives message 6, VERSUCHE BITTE WIEDER. He is then in state 3. A response of 2 for NEIN will give him 3 messages whose pointers start at position 4 in the vector. They are messages 3,9, and 2.

The lesson may come to a logical end or keep cycling back through previous states.

Page 1 of 1

SCRIPT Decision Table

States

Inputs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	2 2 1	3 1 3	3 3 7	1 1 10											
2	2 2 1	4 3 4	4 3 4	1 1 11											
3															
4															
5															
6															
7															
8															
9															
H	1 1 12	2 1 12	3 1 12	4 1 12											

Legend

NS
NCM
VPTR

For tables with more than 15 states attach a second form to the right edge of this one.

SCRIPT Message Vector

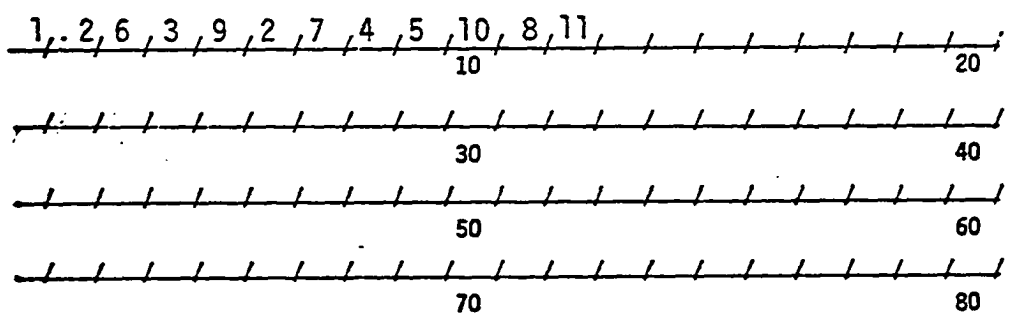


Figure 7. SCRIPT decision table and message vector form.

SCRIPT Message Form

MESS. NO.	MESSAGES (less than 61 characters total)
1	ZWEI UND ZWEI IST FUNF, NICHT WAHR?
2	1) JA 2) NEIN
3	DU HAST RECHT
4	DIESE IST VIER. xxx x
5	DIESE IST FUNF. xxx xx
6	VERSUCHE BITTE WIEDER.
7	ACH; DU LIEBER. LERNE ZAHLEN.
8	DAS IST ALLES.
9	DO YOU WANT THE NEXT LESSON?
10	THEN REQUEST LESSON G2.
11	NO HELP NEEDED.

Figure 8. SCRIPT message list form.

CHAPTER V

FUNCTIONAL DESCRIPTION OF SCRIPT

1. Program Units

There are program units which initialize the files, add new lesson modules, and perform other housekeeping functions. These are not very interesting and will be left to the last.

POLL

This is the main program-main in the sense that it is the vehicle for calling other units into play. POLL does not hold much of the logic. Its primary functions are to determine what lesson the users desire, sense what terminals are ready, set the lines of the ready terminals to receive, time the users to warn them if there is no communication, and to set terminal partition parameters initially. POLL has one other valuable function, providing a place to branch from and return to when interrupts occur.

All the other program units are subroutines or functions called into action by other program units.

ILSØ3

This is the interrupt level subroutine provided by LOGICON to go with the LI/ON. It was modified to mask out interrupts from the terminals while an interrupt is being processed.

LMCC

When ILSØ3 determines that an interrupt has come from the LI/ON it

branches to the interrupt servicing portion of LMCC. LMCC sets flags giving the cause of the interrupt and passes them on to the program USER.

LMCC also involves sections used by other assembler written routines which are FORTRAN callable to receive or transmit messages, test for busy, mask interrupts, etc.

LMCC was modified to provide one extra function, that of turning off a busy flag for a particular line.

USER

When branched to from LMCC, this assembler routine puts the information about the interrupt into COMMON, then determines the cause of the interrupt, and branches to the particular routine needed. This and the following routines are not from LOGICON.

TERM & SERV

These routines are used if an interrupt occurs due to the reception or transmission of an end-of-transmission signal. (This is a line feed in messages coming from the terminal. It is an ASCII EOT-numeric value, 4- in transmissions from the computer.)

TERM does the immediate servicing to handle the interrupt. The user's time limit is updated if the line is in receive mode and a transaction stack is set. In transmit mode the transaction flag indicator is flagged. SERV does the actual logic processing of interrupts that are stacked. It does so when the interrupt state is past.

If the EOT came in transmit mode SERV checks parameter 3 in the partition for the line associated with the interrupt. That will indicate whether there are further messages to be sent. If so, it branches to MODUL (see below) and the return from MODUL sets a flag to indicate transmission is needed. If

parameter 3 indicates no further messages are pending a flag is set to put the line in receive mode. In any case a return to USER, LMCC, ILSØ3, and finally back to the main program is made.

If the EOT comes when the line is in receive mode, an analysis of the input must be made. First, a check is made to see if the user is in instruction mode or calculate mode. If the latter, then a branch to CALC is made. If in instruction mode, then the acceptable inputs are single digits indicating a multiple response or a control command of the form $c. The c may be one of the letters E,H,C,R,S, or L meaning exit from the module, give some extra help, go into calculate mode, return to instruction mode, save his partition, or load his partition from disk, respectively. Only the first several characters are scanned; if all are blanks, a retype is requested.

If the first non-blank character is neither a digit nor $, the user is asked to retype his response. If the character is $, the next character is examined. If that character is E then the line is deactivated. If it is H, then MODUL is called with an argument of zero. This will signify MODUL to take the action given in the bottom row of the lesson decision table for the current state of the user. A C after the $ will cause the mode to be set to calculate. An R will set the mode flag back to instruction mode.

An $S will cause the terminal partition to be stored on disk. The mode and state of the lesson will remain the same, and then the lesson continues. The saving is done under the user's special identification number. There is no attempt at security to prevent users from using the wrong number. Only one partition will be saved under a given number. An $L will cause the partition for that user to be loaded from disk. Upon completion the mode and state of the lesson as it applied to that terminal will be the same as when the partition was saved. However, if the lesson module currently in

core is not the same one the user will be notified.

If a digit is the first non-blank character its value is passed to MODUL. Upon return a flag is set indicating that transmission of the message set up by MODUL is needed.

In any case when TERM is entered the time parameter in the partition is updated to indicate the next time a time warning would be given.

BREAK

BREAK can be used to interrupt transmission or reception of messages or to gain the system's attention when the terminal is turned on. When first entered, the routine sets the time parameter, sets the line not busy, and then determines whether the line was already active or not. If already active a flag is set to put the line in receive mode, and it returns. If the line has not been previously active, the partition active flag is set, a system message is set up - such as READY. TYPE #ID--, a flag is set to indicate transmission is needed, and it returns.

MODUL

This unit is given the number of the input response. This together with current state determines an entry in the decision table. The entry is broken down to produce the next state, the number of consecutive messages to send, and the pointer into the message vector where the message pointers start.

Then the first message is retrieved and put into the appropriate terminal buffer. If the number of messages is greater than 1, the next one is retrieved and inserted in the buffer. Idle characters are inserted between messages to overlay the first EOT and provide time for a carriage return at the terminal. The message vector pointer is increased by one and the count

of the number of consecutive messages to send is decreased by one each time a message is loaded into the buffer.

At the entry to MODUL the message count is checked and, if it is positive, the next message is sent. In this case there is no change of state or access of the decision table.

MESG

This little routine simply loads a system message into the buffer for a terminal. It sets the busy flag off, and then initiates transmission of the message.

CALC

At present CALC is a very rudimentary program to analyze an expression consisting of a function and argument or two numbers with an infix operator. The operators used are +,-,*,/,and**. The functions are LOG, SIN, COS, and EXP. Arguments and operands are simple numbers. No variables are used. When an expression is evaluated its result is transmitted. The purpose of the routine is only to allow simple calculation to help in giving answers to questions in the lesson modules.

PSAVE and PLOAD

These routines are used by TERM when the special commands $S and $L are given. PSAVE will store certain pointers from the terminal partition in the disk file for partitions. They will be stored in the record corresponding to the identification number under which the user signed on. PLOAD reverses the process.

By using $S and later $L the user can leave in the middle of a lesson and come back later to continue where he left off.

ADLSN

When new lessons are to be added to those already on disk, this stand-alone program reads the input, updates the lesson index, packs the data into its stored form, and enters it on the disk.

The data to be provided should be in the following form.

1. Message vector card(s): The format is 20I4. A field of zero (or blanks) serves as the end-of-vector signal. If the vector is exactly a multiple of 20 in length, then an extra blank card should be added so there will be a zero field read.

2. Dimension card: The number of rows and columns of the state/action table is given. Format is 2I4.

3. Decision table cards: The entries for the decision table are punched one to a card. For each entry NS, NCM, and VPTR are punched in 3I4 format. The cards are put in column order. The number of entries is the product of the numbers of rows and columns.

4. Message cards: Each message is punched on one card with the message number in columns 1-3 and the message in columns 5-65. A card with message number of zero signals end of the set of messages.

The decision table entries are packed into one word and entered into a disk file. The messages are translated into ASCII, packed two characters per word, and entered into the disk file. Both the decision table entries and the messages are filed according to a displacement factor obtained from the system parameter file. These displacements are put into an index entry for the lesson module. The displacement factors in the system parameters are updated to point to the end of the last entries.

INIT

This program simply initializes the system files prior to adding lesson modules. The symbols needed to recognize terminal inputs are entered into the system parameter file. Various system messages are read in, converted to ASCII, packed, and entered in the system parameter file, also.

CHAPTER VI

EVALUATION

1. STRIPE

The goals for the information system were given in the introduction. The degree to which they were met is as follows:

1. The system is running on an IBM 1130 with a single disk having a capacity of 1 M bytes and 16K bytes of main storage.

2. On one data base of student records using real data the storage efficiency is between 92% and 95%. The variation depends on whether records have been just enlarged and have some unused space or are essentially full. Suppose records had the form of a mandatory block of 112 bits and a variable field with 10 subfields each averaging 40 characters. The overhead would be 30 bits in the mandatory block and 160 bits in the subfields. Total bits in the variable field would average $10 \cdot (40 \cdot 5\ 1/2 + 16) = 2300$. Total bits would be $2300 + 112 = 2412$. The efficiency would be $(2412 - 190)/2412 \simeq 92\%$.

3. Additions, modifications are easy to make in a batch process. The times observed for additions of new records have ranged from 750 to 1200 records/hour. This timing is dependent on whether category lists are maintained, the physical positioning of the files, the size of the master file, and whether multiple disk drives are used. A dramatic decrease in movement of the disk arm will be observed when the master file is on one drive and the other files are on another. Timing in the neighborhood of 1800 to 2400 records added per hour should be achievable.

4. Input is not of a generalized format. Hence it is not as easy to adapt to a new format as in some systems. On the other hand the user can be totally flexible in writing his input routines which outweighs the disadvantages. This means that his main responsibility is to put the data into the proper slots in the common I/O buffer

5. The query function has been described. It works reasonably efficiently, is easy to use, and is capable of expansion to other functions.

6. As previously explained the system does handle multiple disk drives.

7. The flexibility exists to add new fields to records even where those fields were not originally planned for. The logical file may be enlarged without rebuilding the existing file.

8. To transfer the system to a new computer having a FORTRAN compiler would involve writing new bit manipulation routines in assembler. There are few of these, so the task would not be hard.

STRIPE has met the goals set for it, with the possible exception of the goal of easy adaptability to differing input formats. This was not done because in developing the system it was found that generalizing the input significantly slowed program execution. Still, the writing of short I/O routines seems to be a relatively easy task.

To get a better picture of how STRIPE compares with other file systems in use a questionnaire was sent out to members of CUETUG. Thirty-five descriptions of administrative files were evaluated. The mean efficiency was 51.5%. The range was from 21% to 80%. A less formal investigation of file structures in more sophisticated computer centers seemed to indicate a slightly higher efficiency. However, on the average, it is unlikely to be much more than 60%.

The significance of these figures lies in this. With broad use of the

techniques used in STRIPE, the effective storage space at many computer centers would increase by half.

2. SCRIPT

The goals for SCRIPT were also given in the introduction.

1. Several instructors have learned to write SCRIPT lessons in less than 30 minutes. A seventh grader has done the same.

2. The system can be used for either instruction or testing. The automatic recording of scores has not been implemented.

3. Diagnostic information relative to the lesson's clarity are provided. When the student asks for help (using $H) a record is kept of the state and input at which help was needed.

4. SCRIPT is running now set up for 8 terminals. Memory space is not available for more in the 16K byte system.

5. Response time for an 8 terminal system has only been calculated. The hardware available for development included only one teletype. The interface has just two line adapters. To exceed 3 seconds average response time with 8 terminals in use, the average service time would have to be above .375 seconds. Since the equipment operates on an interrupt system, once a message is sent to a terminal the computer can go on to service another. Even if every user made a request for service each second, the system could handle it.

6. The cost of using any system such as SCRIPT would be prohibitive unless well used. If SCRIPT were used as much as 8 sessions a day for 200 days per year, the cost would be about 70¢/session. This figure is arrived at by allocation about 50% of the cost of the basic computer to the terminal use. This amounts to about $35,000. Nearly all the cost of the terminals and

the interface is, of course, allocated to the academic use. This comes to $16,000. The total is $51,000. If we use only 5 years to prorate this cost, the yearly amount of $10,200 divided by 12,800 sessions gives the above cost per session.

This cost calculation is made with the assumption that between sessions other work could be run. It should be recognized that no consideration has been given to costs of development of lesson modules. In SCRIPT or any other system this will be significant if it is not spread over a large volume of users. Sharing of lessons among educational institutions is very necessary. On the credit side it can be pointed out that by using some hardware from other sources than the mainframe manufacturer considerable savings can be made - as much as $300 per month. This would amount to enough to pay for a lot of development.

On balance, then, though there is further work to be done, the goals have been met.

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Numerous discussions at conferences of CUETUG and the Association for the Development of Instructional Systems added ideas in this development.

APPENDIX A

PROOF THAT THE LINEAR QUOTIENT HASH ALGORITHM WILL PROBE ALL SLOTS OF A FILE IF THE DIVISOR IS PRIME

Assume the divisor, D, is a prime integer and K is the principal key. $Q = \lfloor K/D \rfloor$. $\lfloor x \rfloor$ means FLOOR(x). If this makes Q = 0, set Q = 1. Let p_0 be the remainder when K is divided by D, or

$$p_0 = K - \lfloor K/D \rfloor \cdot D$$

Then we recursively define

$$p_{i+1} = (p_i + Q) \bmod D + 1$$

Without losing generality we can assume $1 \leq Q \leq D$ since the p_i's are calculated modulus D.

Obviously, the sequence $p_0, p_1, \ldots p_i, \ldots p_{D-1} = \{p_i\}$ will have to start duplicating by the D+1 term. We need to show it can not duplicate earlier.

By the construction of $\{p_i\}$ there will be subsequences S_1, S_2, etc. of $\{p_i\}$ in which the sequence has been increasing in say, S_j, decreases going to S_{j+1}, increases through S_{j+1}, decreases going to S_{j+2}, etc. As an example, consider D = 11, Q = 3, and p_0 = 2.

$$\{p_i\} = \{2,5,8,0,3,6,9,1,4,7,10,2,5,8,\ldots\}$$

We see that duplicating begins on the 12th element. There are three subsequences as described.

$S_1 = \{2,5,8\}$ $\quad$ $S_2 = \{0,3,6,9\}$ $\quad$ $S_3 = \{1,4,7,10\}$

It is easily seen that the number of these subsequences is Q. The number of elements in each S_j is either $\lfloor D/Q \rfloor$ or $\lfloor D/Q \rfloor + 1$.

Now, suppose the first elements of S_j and S_k are equal. (Taking the case

of the first elements should suffice.) That is, $s_{j1} = s_{k1}$. That means s_{j1} was obtained by going (k-j) times around the "modular clock," starting from s_{k1}, or

$$s_{j1} \equiv s_{k1} + (k-j) \cdot D$$

Now if

$$s_{j1} = p_i \text{ and } s_{k1} = p_m,$$

then

$$s_{j1} = p_i \equiv p_m + (m-i) \cdot Q \equiv s_{k1} + (k-j) \cdot D$$

and we have

$$(k-j) \cdot D = (m-i) \cdot Q$$

$$D = \frac{m-i}{k-j} \cdot Q$$

If (k-j) = Q, then p_i and p_m are D elements apart which is as it should be for duplication. But if (k-j) $\neq$ Q where there are Q of those subsequences then D, an integer, is equal to the product of two integers, and, thus, D is not prime. The case where Q = 1 is trivial.

APPENDIX B

SAMPLE SCRIPT LESSON IN LIMITS OF INFINITE SERIES

Page 1 of 1

SCRIPT Decision Table

States

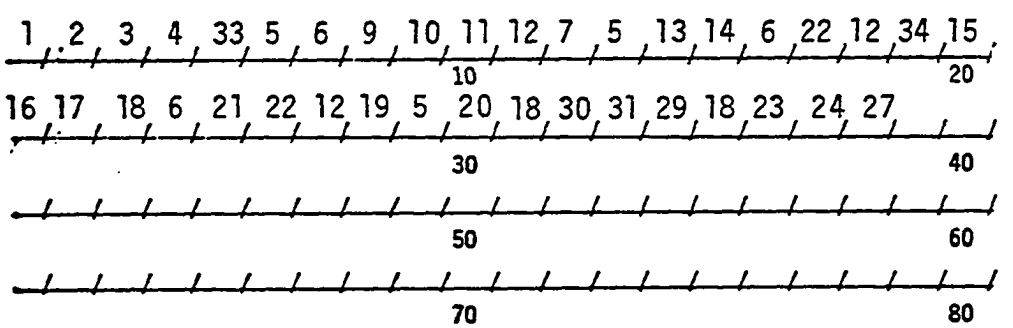
Inputs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	2 4 1	2 1 6	4 2 14	5 4 20	5 2 28	6 1 6	8 2 34	7 2 26							
2	2 4 1	3 5 7	7 3 16	5 4 20	6 2 30	7 3 25	1 3 36	7 2 26							
3	2 4 1	2 2 12	3 1 19	4 1 19	5 1 19	6 1 19	7 1 19	8 1 19							
4	2 4 1	2 1 6	3 1 19	4 1 19	5 1 19	6 1 19	7 1 19	8 1 19							
5	2 4 1	2 1 6	3 1 19	4 1 19	5 1 19	6 1 19	7 1 19	8 1 19							
6	2 4 1	2 1 6	3 1 19	7 4 24	5 1 19	6 1 19	7 1 19	8 1 19							
7															
8															
9															
H	1 1 5	2 1 5	3 1 5	4 1 5	5 2 32	6 1 5	7 1 5	8 1 5							

For tables with more than 15 states attach a second form to the right edge of this one.

Legend

NS
NCM
VPTR

SCRIPT Message Vector



SCRIPT Message Form

MESS. NO.	MESSAGES (less than 61 characters total)
1	WE'VE SEEN THAT SOME SERIES SU
	CH AS
2	1/3 + 1/9 + 1/27 + . . . CONVERGE
	TO A LIMIT.
3	WHAT IS THE LIMIT OF THIS ONE?
4	1)1/2 2)1/2 3)1/3 4)2/5 5)13/27
	6)NONE
5	LET'S TRY THAT AGAIN.
6	THAT'S RIGHT.
7	SINCE SOMETHING IS ADDED TO 1/
	3, THE SUM MUST BE BIGGER.
8	IT SEEMS WE MUST GO BACK TO TH
	E PREVIOUS LESSON.
9	WE'VE ALSO SEEN THAT SOME SERI
	ES SUCH AS
10	1/2 + 1/3 + 1/4 . . . DIVERGE TO I
	NFINITY.
11	NOW CONSIDER 5-5+5-5+ . . .
12	DOES IT 1)CON. OR 2)DIV.
13	OK, WHAT IS THE LIMIT?
14	1)Ø 2)5 3)-5 4.)1Ø 5)-1Ø 6)NONE
15	IF SO, EVENTUALLY THE SUMS GET
	ARBITRARILY
16	CLOSE TO THAT LIMIT, AND REMAI
	N THERE.
17	WILL THE SUMS EVER STAY WITHIN
	1 OF THE LIMIT?
18	1)YES 2)NO
19	IN HOW MANY TERMS?
20	THEN DOES IT CONVERGE?
21	THAT MEANS IT DIVERGES.
22	THEN HOW ABOUT (5-5)+(5-5)+(5-
	5)+. . .?
23	YOU SEEM TO HAVE THE RIGHT IDE
	A
24	THAT IS ALL TODAY.
25	GET SERIOUS.

SCRIPT Message Form

MESS. NO.	MESSAGES (less than 61 characters total)
26	TO GET THAT ANSWER YOU MUST HA
	VE CHANGED THE SERIES.
27	THIS SHOULD LEAVE YOU THINKING
	ABOUT ASSOCIATIVITY AND
28	COMMUTATIVITY IN INFINATE SERI
	ES
29	BUT ISNT (5-5)+(5-5)+...EQUAL
	TO 5-5+5-5+...BY ASSOC. LAW?
30	NO, THERE IS ALWAYS ANOTHER Ø
	OR 5, SO IT CANT
31	STAY WITHIN 1 OF EITHER.
32	FOR ANY FINITE NUMBER OF TERMS
	NO HELP PROVIDED.
	, THAT IS.
33	NO HELP PROVIDED.
34	ANSWER 1 OR 2

The following is a short segment of a lesson written by a seventh grade student. It took less than 20 minutes explanation to show him how to use SCRIPT. (No corrections have been made. This is just as he wrote it the first time.) This is the result exactly as it came out on the teletypewriter.

```
READY. TYPE #ID
#6
TYPE 1 TO BEGIN
1
GEOMETRY
IF YOU TOOK THE DEGREE OF
EACH ANGLE IN A TRIANGLE AND ADDED THEM
TOGETHER, WHAT WOULDYOU HAVE*
1)180 2)360 3)270 4)NONE OF THESE
2
WRONG TRY AGAIN
1)180 2)360 3)270 4)NONE OF THESE
$H
NO HELP NEEDED
1
RIGHT DO YOU WANT THE NEXT LESSON
1) YES 2) NO
$S
1
LINES AND PLANES LESSON TWO
HOW MANY PLANES CAN INTERSECT TWO POINTS IN A
LINE AND 1 POINT NOT ON THE LINE
$L
2
THATS ALLTHANK YOU
```

APPENDIX C

DESCRIPTION OF STRIPE APPLIED TO AN ACADEMIC RECORD SYSTEM

To illustrate the use of STRIPE the use of the files and the layout of files in those fields will be shown. This gives more detail to the explanations given in Chapter II.

The purpose of this application of STRIPE is to hold the academic cumulative record of students in a college.

1. Category File

This file concerns faculty members who are advisors. The advisor is arbitrarily assigned a number which is used as the record number of his entry in the file. Records in the file are of two types. The primary type contains a pointer to the first secondary type record chained to the primary, a count of the number of advisees for this advisor, and the advisor's name. The second record contains a pointer to the next secondary record, if any, and pointers to records in the master file of advisees. All these records are 12 words each. For both the secondary record chains and the master record pointers, zero means null. These records are not bit packed since the nature of the information is such that there would be little advantage.

2. Descriptor File

This file contains information about courses. It, too, has primary and secondary records.

The primary records list information about the course itself as shown in the table below, including a pointer to a secondary record. Primary records are bit packed.

The secondary record's first word is a pointer to the next secondary record, if any. The other words are pointers into the master file to students enrolled in the course. Secondary records are one field/word.

Field	Description	No. of bits
1	Numeric code for course	16
2	Pointer to secondary record	16
3	Record status	3
4	Department number	6
5	Course number	9
6	Section	8
7	Course credit	6
8	Quarter and year	8
9	Number enrolled	8
10	Maximum number allowed	8
11	Hour given	4
12	Instructor code number	7
13	Building and room	16
14	Building and room	16
15	Exam period	13
16	i) Days given 16 characters	128
	ii) Course title 16 characters	128
	iii) Instructor name 10 characters	80
	TOTAL	480 bits = 30 words

The quarter and year is coded with fall, winter, spring and summer having codes 1, 2, 3, and 4, respectively. Thus, the code for spring, 1973 is 373. For internal storage 150 is subtracted, and 223 is stored. For summer, 1973 the code is 473. For internal storage 470 is subtracted, and 3 is stored. This system will work until the year 2000.

The identification number of the course is a hash of the department, course and section. The system checks to be sure there is not a duplicate hash number when course records are entered. If there is, the section number is changed.

3. Master File

The contents of these records are given in the following table. Depending on the length of the variable field an initial size of 100 words provides space for nearly a year's worth of courses.

Field	Description	No. of bits
1	Record status: bit 0=opt. block present, bit 1=vbl field present, bit 7=error bit	8
2	Length of vbl field in words	7
3	Number of words in record	9
4	Number groups of fields in vbl block	6
5	Id. No. (first)	10
6	Id. No. (second)	10
7	Id. No. (third)	0
8	Degree	2
9	Sex	2
10	Class	2
11	First major	5
12	Second major	5
13	First advisor	7
14	Second advisor	7
15	First dorm.	5
16	Second dorm.	5
17	Course crd. att. here (x10)	11
18	C.C. achieved here (x10)	11
19	Total grade pts. (x10)	16
20	Grade pt. average (x1000)	14
21	C.C. achieved elsewhere (x10)	11
22	Total course cred. (x10)	11

Master File detail continued:

Field	Description	No. of bits
23	Academic status	4
24	Geographic region	6
25	School requirements met	16
26	Residence code	4
27	Real mode field	32
28	Unused	13
29	Birth date month	4
30	Birth date day	5
31	Birth date year	7
32	Date grad. (year) from H.S.	7
33	H.S. rank in class	10
34	Size of H.S. grad. class	10
35	Grade pt. ave. in H.S. (x1000)	14
36	SAT, verbal	10
37	SAT, math	10
38	Years of Eng. in H.S. (x2)	3
39	Years of Soc. Sci. in H.S. (x2)	3
40	Years of For. Lang. in H.S. (x2)	3
41	Years of Math. in H.S. (x2)	3
42	Years of Hist. in H.S. (x2)	3
43	Years of Nat. Sci. in H.S. (x2)	3
44	H.S. credits	5
45	Unused	12
46	Begin variable field	
	Variable field: 4 possible subfields 1) name, 2) birthplace, city & state, 3) address 1, 4) address 2 Form of each subfield: first word has subfield number in first 8 bits, no. of words in subfield in second 8 bits. Lines of address separated by local code. Use * here. Average length if all subfields are in might be (in words) name=6+birthplace=6+addr 1=15+addr 2=15. Total 42 words.	

Master File detail continued:

Field	Description	No. of bits
	Begin variable block of groups.	Pointer rel. to block.
47	Dept.	6
48	Course no.	10
49	Section	8
50	Course credits (x10)	8
51	Grade	8
52	Date (quarter and year code)	8
53	Dummy	0

Summary of Space for Recrod

1	Fixed mandatory block	14 words
2	Optional fixed block	7 words
3	Variable field (average approx.)	30 words
4	Variable block (average approx.)	108 words
		159 words

Efficiency if 160 word record is filled with 36 classes

Block	Bits used	Overhead	Minimum required
1	224	39	185
2	112	12	100
3	480	58	424
4	1744	16	1728
	2560		2437

Efficiency = 2437/2560 = .952

Efficiency could be as low as .95 if measured at the time a record has just been enlarged by 20 words and only 1 new group has been put in.

The other files are just as shown in Chapter III. Therefore, they are not repeated here.

Once the files and record layouts have been determined the files are defined for the monitor system. Then program INFIL is used to put system

messages and parameters into the files and to initialize the master file. Then ADCAT and ADDSC can be run to set up categories and descriptors.

APPENDIX D

PROGRAM LISTINGS FOR STRIPE

Main programs are listed first in the order described in the text. Subprograms are given in alphabetical order.

```
      INTEGER SZINX,DCLSL
      INTEGER ECF(320),BLANK(38),CHAR(40)
      INTEGER FIELD(57),COMM(50)
      EQUIVALENCE (ECF(320),DCLSL)
      EQUIVALENCE (ICPF,COMM(20)),(IFXF,COMM(19)),(IVBL,COMM(21))
      DATA K32/32000/,K0/0/
      DATA NCRD,IZ,SZINX/2,0,1024/,EOF/320*'$'/'/,BLANK/38*' '/
      DATA CHAR/'E','T','A','O','I','N',' ','S','H','R','D','L','U','C',
     +          'M','F','W','Y','P','0','1','2','3','4','5','6','7','8',
     +          '9','V','B','G','K','Q','J','X','Z','.',',','.','E'/
      DEFINE FILE 1 8160, 20,U,N1 ,2 300,12,U,N2 ,3 800,30,U,N3
      DEFINE FILE 4 320,1,U,N4 , 5 1024,5,U,N5 ,6(42,15,U,N6)
      DEFINE FILE 8(96,10,U,N8),7(40,60,U,N7),9(50,4,U,N9)
  100 WRITE(1,930)
  930 FORMAT('TYPE WHICH FILE TO INITIALIZE'/'1,2,3,4,5,6,7,8, OR 9 IN I
     +2 FORMAT'/'10 FOR EXIT OR 11 FOR ALL FILES'
      READ(6,902)I
  902 FORMAT(I2)
      IALL 1
      GO TO(1,2,3,4,5,6,7,8,9,1000,1011 ,I
 1011 IALL 2
C...FILE1. IF MULTIPLE MASTER FILES USED, INITIALIZATION OF THEM
C...MUST BE ADDED
    1 DO 10 I=1,8145,16
   10 WRITE  1 I ECF
      WRITE(1'1)(ECF(J),J=1,7),K32,IZ
      GO TO 100,2 ,IALL
C...FILE 2
    2 DO 20 I 1,100
   20 WRITE(2'I)IZ,IZ,(BLANK(J),J=1,10)
C...LINK TOGETHER LAST 200 RECORDS IN CATEGORY FILE FOR FREE AREAS
      DO 25 I=101,299
      J=I+1
   25 WRITE(2'I)J,(ECF(K),K=1,11)
      WRITE(2'300)K0,(ECF(K),K=1,11)
      GO TO 100, 3 ,IALL
C...FILE 3
    3 DO 30 I=1,497
   30 WRITE(3'I)IZ,(BLANK(J),J=1,29)
      DO 35 I= 500,800
   35 WRITE(3'I-1)I,(IZ,K=1,29)
      WRITE(3'800)(IZ,I=1,30)
      GO TO(100,400),IALL
C...FILE 4
    4 WRITE(1,921)
  921 FORMAT('PUT COMM CARDS IN')
      PAUSE
  400 READ(2,920)COMM
  920 FORMAT(20I4)
      READ(2,920)FIELD
      WRITE(4'1)COMM
      WRITE(4'125)DCLSL
C...PUT IN ARRAY TO USE IN A1A3
      DO 45 I=126,165
   45 WRITE(4'I)CHAR(I-125)
C... PUT IN LAYOUT OF MASTER RECORD
      KSM=0
      KK=51+IFXF+ICPF
      DO 46 I=51,KK
      WRITE(4'I)KSM
   46 KSM=KSM+FIELD(I-50)
      KSM=0
      K=KK+1
      KK=KK+IVBL+1
      DO 49 I=K,KK
      WRITE(4'I)KSM
   49 KSM=KSM+FIELD(I-50)
      GO TO 100,  5 ,IALL
C...FILE 5
```

```
    5 DO 50 I 1,SZINX
   50 WRITE 5 I IZ,IZ,IZ,IZ,IZ
      GO TO 100,600 ,IALL
C...FILE 6
    6 WRITE(1,919)
  919 FORMAT('PUT REQUIREMENT MSGS IN READER')
      PAUSE
C...MUST BE 42 REQUIREMENT MSG CARDS
  600 DO 60 I=1,42
      READ(NCRD,935)(BLANK(J),J=1,15)
  935 FORMAT(15A2)
   60 WRITE(6'I)(BLANK(J),J=1,15)
      GO TO 100,700 ,IALL
C...FILE 7
C...PUT 20 BA FOLLOWED BY 20 BS CARDS.  USE BLANKS FOR UNUSED RECORDS
    7 WRITE(1,910)
  910 FORMAT('PUT REQUIREMENT DESCR. IN READER')
      PAUSE
  700 DO 70 K=1,40
      READ(NCRD,912)IDRG,M,N
  912 FORMAT(3(I2,1X))
      IF(IDRG)71,71,61
   61 MN=M*N
      IF(IDRG-40 )62,62,7
   62 IF(MN-58)63,63,7
   63 READ(NCRD,913)(BLANK(I),I=1,MN)
  913 FORMAT(11I7)
      WRITE(7'IDRG)M,N,(BLANK(I),I=1,MN)
   70 CONTINUE
   71 GO TO 100,800 ,IALL
C...FILE 8
    8 WRITE 1,914
  914 FORMAT 'PUT ERR MSGS IN RDR'
      PAUSE
  800 DO 80 I=1,96
      READ(2,900)(BLANK(J),J=1,10)
  900 FORMAT(10A2)
   80 WRITE(8'I)(BLANK(J),J=1,10)
      GO TO 100,1900 ,IALL
C...FILE 9
C...USE 50 CARDS.  PUT IN BLANKS FOR UNUSED RECORDS
    9 WRITE(1,915)
  915 FORMAT('PUT IN DEPT. ABBR. & LTR GRADE CARDS IN RDR')
      PAUSE
 1900 DO 90 J=1,50
      READ(NCRD,916)KA,KB
  916 FORMAT(2A2)
   90 WRITE(9'J)KA,KB,BLANK(37),BLANK(38)
      GO TO 100
 1000 CALL EXIT
      END
```

```
** EXEC

      INTEGER COMM(165),FLPTR(4),STURC(340),BUFF(67)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      DATA IY/ Y /,IN/ N /
C...EXECUTIVE ROUTINE
C...BUFF(67) CORRESPONDS TO SPTR USED IN QUERY
      DEFINE FILE 4 320,1,U,N4
      BUFF(67)=0
      IERFL 1
      READ(4'1)COMM
    4 WRITE(1,900)
  900 FORMAT('SET SWITCHES')
      CALL DATSW(15,J)
      IF(J-1)5,9,5
    5 WRITE 1,901
  901 FORMAT  0-EXIT / 1-ADD ADVISOR / 2-ADD COURSE / 3-A
     CDD STUDENT / 4-ADD COURSE TO STUDENT / 5-PUT GRADES /'6-REQUIREMEN
     CT SHEETS'/'7-GARBAGE COLLECTION'/,'8-MODIF STUD. CRS.'/,'9-MODIFY
     CFIXED PART, STDNT REC.'/,'10-DROP CRS FROM STUD.'/,'11-DELETE MAST
     +ER REC.'/,'12-QUERY'/,'14-UTILITY'/)
    9 PAUSE
      DO 10 I 1,16
      CALL DATSW I-1,J
      IF J-1 10,15,10
   10 CONTINUE
      GO TO 5
   15 K I-1
   16 WRITE 1,902 K
  902 FORMAT   IS SWITCH  ,I2,  RIGHT  TYPE Y OR N AND THEN EOF.
      READ 6,903 IA
  903 FORMAT A1
      IF IA-IY 20,30,20
   20 IF IA-IN 16,5,16
   30 GO TO 50,60,70,80,90,100,110,120,130,140,150,160,170,180,190 ,I
   50 CALL EXIT
   60 CALL LINK(ADCAT)
   70 CALL LINK(ADDSC)
   80 CALL LINK(ADMAS)
   90 CALL LINK(ADVEL)
  100 CALL LINK(MDVEL)
  110 CALL LINK(RQUIR)
  120 CALL LINK(GAREG)
  130 CALL LINK(MODRC)
C...SET UP MODIFICATION PROGRAM TO MODIFY ANY PART OF RECORD
  140 GO TO 190
  150 CALL LINK(GPDRP)
  160 CALL LINK(CRCP)
  170 CALL LINK(QUERY)
  190 CALL LINK(UTLTY)
  180 CONTINUE
      WRITE(1,904)
  904 FORMAT('NOT AN OPERATIONAL ROUTINE')
      GO TO 4
      END
```

```
**ADCAT

C...THIS ROUTINE ASSUMES FACULTY IS ASSIGNED NUMBERS 1-VALUE OF COMM(27)
      INTEGER COMM(165),FLPTR(4),STURC(340),BUFF(41)
      INTEGER ADVSR(10),BLANK(15)
      COMMON CCMM,FLPTR,STURC,IERFL,BUFF
      DATA K99/    0/, BLANK/15*16448/,KEOD/'*'/
      EQUIVALENCE (ADVSR(1),BUFF(2)),(NUM,BUFF(1)),(KEST,BUFF(41))
      EQUIVALENCE (NCRD,COMM(34)),(KVAIL,COMM(30))
      DEFINE FILE 2(300,12,U,N2),4(320,1,U,N4),8(96,10,U,N8)
C...ADDS NEW CATEGORY RECORDS
C...RECORD LAYOUT OF CATEG. RECORD IS
C...WORD 1 POINTER TO INVERTED LIST
C...WORD 2 NUMBER IN LIST
C...WORD 3 BEGINNING OF NAME(10 WORDS)
C...INVERTED LIST IS MAINTAINED IN THE RECORDS FOLLOWING THE CATEGS.
C...CHAINS ARE IN FIRST WORD.  IN ACTIVE RECORDS THE FOLLOWING
C...11 WORDS HOLD POINTERS TO MASTER RECORDS.  CHAIN OF 0 IS END-OF-LIST
    5 CALL RCATC
      IF(KEST-KEOD)6,99,6
    6 IF(NUM)999,5,13
   13 IF(NUM-CCMM(27))10,10,999
   10 READ(2'NUM)II
      IF(II)999,11,999
   11 COMM(26)=CCMM(26)+1
      WRITE(2'NUM)KVAIL,K99,ADVSR
      KSV=KVAIL
      READ(2'KVAIL)KVAIL
      WRITE(2'KSV)(K99,I=1,12)
      IF(CCMM(26)-CCMM(27))5,12,12
   12 CALL ERR(25)
      IERFL=1
   99 WRITE(4'1)CCMM
      CALL LINK  EXEC
  999 CALL ERR(18)
      IERFL=1
      GO TO 5
      END
```

```
** ADDSC

      INTEGER COMM(165),FLPTR(4),STURC(340),BUFF(41)
      INTEGER CRINX(797),BUFF1,BUFF2
      INTEGER ENCSF,SZCRS
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (BUFF2,BUFF(2))
      EQUIVALENCE (KODE,BUFF(41)),(BUFF(1),BUFF1),(KVAIL,COMM(37))
      EQUIVALENCE(ENCSF,COMM(25)),(SZCRS,COMM(22)),(IDIV2,COMM(24))
      DATA KECD/'*'/,IZ/0/
      DEFINE FILE 3(800,30,U,N3),4(320,1,U,N4),8(96,10,U,N8)
C...ADDS NEW DESCRIPTOR RECORDS
C...FIRST READ IN INDEX OF DESCRIPTOR IDS FROM DISK FOR HASH1 TO USE
      DO 2 I=1,IDIV2
    2 READ(3'I)CRINX(I)
    5 IF(ENCSF-SZCRS)20,10,10
   10 COMM(23)=1
      CALL ERR(35)
      GO TO 999
C...RDSCC FILLS IN BUFF.  BUFF(1) IS THE KEY NO. OF THE DESCRIPTOR.
   20 CALL RDSCC
      IF(KECD-KODE)40,999,40
   40 CALL HASH1(BUFF1,CRINX,IR,IDIV2,1)
C...HASH1 WILL NOT PUT IN A DESCRIPTOR WITH DUPLICATE KEY.
      IF(IR)41,41,42
   41 CALL ERR(10)
      IERFL=1
      CALL STACK
      GO TO 20
   42 CRINX(IR)=BUFF1
      BUFF2=KVAIL
      KP=KVAIL
      IF(KP)10,10,70
   70 READ(3'KP)KVAIL
      WRITE(3'KP)IZ
       WRITE(3'IR)(BUFF(I),I=1,30)
      ENCSF=ENCSF+1
      GO TO 5
  999 WRITE(4'1)COMM
      CALL LINK(EXEC)
      END
```

```
** ADMAS

C...ADDS A NEW MASTER RECORD TO THE DATA BASE
      REAL XBUFF(20)
      INTEGER COMM(165),FLPTR(4),STURC(340),BUFF(41)
       INTEGER SZSTU, DOLSL, ADVX(100), NAME( 9),ENSTF ,MPT(12)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (NOADV,COMM(27)),(IDIV,COMM(7)),(INSIZ,COMM(17)),
     +            (ICM14,COMM(14)),(NOFLD,COMM(19)),(COMM(1),ICOM1),
     +            (COMM(2),ICOM2),(SZSTU,COMM(3)),(NOSTD,COMM(4))
      EQUIVALENCE (BUFF(41),IFB41),(KVAIL,COMM(30)),(NAME(1),MPT(1))
      EQUIVALENCE (ICOM3,COMM(3)),(ICM28,COMM(28)),(COMM(5),ICM5)
      EQUIVALENCE (IS9,STURC(9)),(IS10,STURC(10)),(COMM(5),ICM5)
      EQUIVALENCE (BUFF(5),IBUF5),(BUFF(6),IBUF6),(BUFF(7),IBUF7)
      EQUIVALENCE (STURC(8),IS8) ,(BUFF(1),XBUFF(1))
C...THE EQUIVALENCING OF MPT AND STURC(321)-(332) IS ONLY
C...OK IF THE INITIAL RECORD IS NOT OVER 320 WORDS
      EQUIVALENCE (MPT(1),STURC(321))
      DATA DOLSL/'$'/, KEOD/'*'/
      DEFINE FILE 1(8160,20,U,N1),2(300,12,U,N2)
      DEFINE FILE 4 320,1,U,N4 , 5 1024,5,U,N5),8(96,10,U,N8)
C...READ IN CATEGORY NUMBERS. NOTE THAT ADVX MUST BE DIMENSIONED BIGGER
C...IF THERE ARE OVER 100 CATEGORIES
       DO 3 I=1,100
      READ(2'I)ADVX(I)
    3 CONTINUE
    5 ENSTF=IGVB(ICOM1,0,11)
      IF(ENSTF-SZSTU+2)20,10,10
   10 ICM5=1
      IERR 17
      GO TO 1000
C...RMASC FILLS IN BUFF.  BUFF(I) CORRESPONDS TO FIELD(I) IN
C...MANDATORY FIXED BLOCK FOR FIELDS 5 THRU NOFLD.  IF
C...NOFLD IS GT 30 A CHANGE MUST BE MADE.  THE ENTRY FOR SUBFIELD 1
C...OF THE VBL FIELD BEGINS IN BUFF(31).  FIELDS 1 THRU 4 OF
C...RECORD ARE COMPUTED IN THE PROGRAM, SO BUFF(1)-(4) UNUSED NOW.
   20 CALL RMASC
      GO TO (27,26),IERFL
   26 IERFL=1
      GO TO 999
C...  IFLG IS TO SHOW WHETHER THE FREE AREA
C...BEING EXAMINED IS POINTED TO BY COMM OR BY A PREVIOUS AREA
C...NEEDED FOR MAINTAINING FREE AREA CHAINS
   27 IF(IFB41-KEOD)1027,999,1027
 1027 IFLG=1
      ICHSC=IGVB(ICOM2,0,11)
      ICHWD=IGVB(ICOM2,12,15)
      ICHSW=ICOM2
      MM=IBUF5
      NN=IBUF6
      NNN=IBUF7
C...MAKE SURE THERE IS A PLACE IN INDEX AND NOT A DUPLICATE
      CALL HSHF2 MM,NN,NNN,KREC,IDIV,1,IPTR)
      IF(KREC)271,271, 28
  271 CALL STACK
      GO TO 20
   28 IF(ICHSC)230,230,228
  230 ICHSC=IGVB(ICOM1,0,11)
      ICHWD=IGVB(ICOM1,12,15)
      ICHSW=ICOM1
  228 CALL RMASR(ICHSW)
C...NEED TO DETERMINE IF THERE ARE AT LEAST 100 WORDS AVAILABLE
C...TO START THE RECORD
      N=IS8
      N90=N/INSIZ+1
C...IADD NEEDED FOR LATER CHECK ON WORD IN SECTOR
C...ON WHICH RECORD STARTS.
      IADD=16-INSIZ/20
      IF(N90-3)29,29,30
   30 N90=3
   29 NXSEC=IS9
```

```
      NXWRD=IS10
      NXSW=IS9
      IDISC=IFLG*N90
      GO TO (31,32,40,45,50,50),IDISC
   32 GO TO (36,31),IFLG
C...THIS SECTION IS FOR N LT INSIZ. THUS THERE IS TOO LITTLE
C...ROOM FOR A RECORD.  GO TO NEXT FREE AREA.
   31 ISVSW=ICHSW
      IFLG=2
      ICHSW=NXSW
      ICHWD=NXWRD
      ICHSC=NXSEC
      GO TO 28
C...THIS SECTION IF IFLG=1 AND  AND N90=2.  I.E. WE ARE IN THE
C...AREA POINTED TO BY COMM(2) AND THE NO. OF WORDS
C...IS BETWEEN INSIZ AND TWICE INSIZ
   36 ICOM2=NXSW
      CALL IPFLD N,X,3
      IN=ICM14+1
      IL=N
      GO TO 60
C...THIS SECTION IF IFLG=1, N90=3.  SAME AREA POINTED
C...TO BY COMM BUT SIZE OF AREA GE TWICE INSIZ
C...HOWEVER SKIP RESETTING IF POINTED TO BY COMM(1)
   40 IF(ICOM2)44,44,39
   39 IF(ICHWD-IADD)41,41,42
   41 ICOM2=IPVB(IGVB(ICOM2,12,15)+INSIZ/20,ICOM2,12,15)
      GO TO 44
   42 ICOM2=IPVB(IGVB(ICOM2,0,11)+1,IGVB(ICOM2,12,15)-IADD,0,11)
C...CHECK TO SEE IF N SHOWS REST OF FILE FREE
   44 IF(N-32000)43,46,46
   46 IF(ICHSC-ICOM3+1)47,47,43
   47 STORC(INSIZ+8)=32000
      GO TO 48
   43 STORC(INSIZ+8)=N-INSIZ
   48 STORC(INSIZ+9)=NXSW
      CALL IPFLD INSIZ,X,3
      IN=ICM14+1
      IL=INSIZ
      GO TO 60
C...THIS SECTION IF N90=IFLG=2. THIS FREE AREA POINTED AT BY
C...PREV. AREA. SIZE IS BETWEEN INSIZ AND TWICE INSIZ. LSTSP IS SECT.
C...SHERE NEXT FREE AREA BEGINS.  LSTWP IS REL. WD. IN THAT SECT.
C...THEY MUST BE PUT INTO THE PREVIOUS FREE AREAS POINTER.
   45 LSTSP=IS9
      LSTWP=IS10
      CALL IPFLD N,X,3
      IN=ICM14+1
      IL=INSIZ
      GO TO 60
C...THIS SECTION IF N90=3, IFLG=2.  THIS FREE AREA POINTED TO
C...BY PREV. AREA. SIZE GE TWICE INSIZ. SECTOR AND WORD POINTERS
C...MUST BE PUT INTO THE PART OF THIS FREE AREA REMAINING FREE.
   50 CALL IPFLD INSIZ,X,3
      IF(ICHWD-IADD)51,51,52
   51 LSTWP=ICHWD+INSIZ/20
      GO TO 53
   52 LSTWP=ICHWD-IADD
      LSTSP=ICHSC+1
   53 CONTINUE
C...CHECK ON N GE 32000
      IF(N-32000)54,55,55
   55 IF(ICHSC-SZSTO+INSIZ)56,56,54
   56 STORC(INSIZ+8)=32000
      GO TO 58
   54 STORC(INSIZ+8)=N-INSIZ
   58 STORC(INSIZ+9)=NXSW
      IN=ICM14+1
      IL=INSIZ
   60 CONTINUE
C     POINTER IN STUDENT FREE AREA TO BE PATCHED AFTER STORC NOT NEEDED
C...NOW GET CATEGORY RECORD FILLED IN
```

```
      IF(ICM28)71,71,61
   61 CONTINUE
      KADV=BUFF(ICM28)
      READ(2'KADV)IPNT,NUM
      CALL INVRT(2,IPNT,12,0,ICHSW,MPT)
      GO TO (71,68),IERFL
C...THIS MEANS THERE IS NO MORE ROOM IN CATEG. FILE. GARBAGE COLLECT
   68 CALL ERR(4)
      IERFL=1
      CALL STACK
      GO TO 20
C...NOW PUT INFORMATION INTO MASTER RECORD
   71 DO 72 I=5,NCFLD
      CALL IPFLD(BUFF(I),123.45,I)
C...THE VALUE 123.45 BEING USED JUST FOR TEST OF REAL MODE FIELD.
C...THAT ARGUMENT SHOULD BE 0 UNLESS FILLED IN FROM RMASC
   72 CONTINUE
C...PUT IN NAME. NAME GOES INTO VBL FIELD. SINCE WE HAVE
C...NO OPTIONAL FIXED BLOCK AS YET. VBL FIELD FOLLOWS MAND. FIXED.
C...NAME STARTS IN 2ND WORD OF FIELD.
C...NO. OF A3 FIELDS IN NAME IS GIVEN IN BUFF(38)
      NONAM=BUFF(38)
      STORC(ICM14+1)=IPVB(1,0,0,7)+NONAM
      K=31
      II=ICM14+2
      III=ICM14+1+NONAM
      DO 174 I=II,III
      STORC(I)=BUFF(K)
  174 K=K+1
      IN=IN+1+NONAM
C...SET RECORD TO INDICATE VBL FIELD
      CALL IPFLD 64,X,1
C...SET LENGTH OF VBL FIELD
      CALL IPFLD(NONAM+1,X,2)
C...NUMBER OF GROUPS OF FIELDS IN VBL BLOCK
      CALL IPFLD 0,X,4
C...ZERO OUT RECORD STARTING WITH UNUSED WORDS.  IN IS FIRST
C...WORD UNUSED IN FIXED PART OF RECORD.
      DO 75 K=IN,IL
   75 STORC(K)=0
      GO TO (175,173),IERFL
C...FILL IN INDEX FILE AND ADD 1 TO NUMBER OF STUDENTS
  175 WRITE(5'KREC)MM,NN,NNN,ICHSW,BUFF(39)
      NOSTD=NOSTD+1
C...PUT RECORD ON DISK
C...KEY OF 1 FOR WMASR MEANS ALSO WRITE AN ADDITIONAL TEN
C...WORDS FOR FREE AREA CHAIN
      CALL WMASR(ICHSW,1)
      GO TO (80,173),IERFL
  173 IERFL=1
      CALL STACK
      GO TO 20
C...CHECK FOR UPDATING POINTER TO LAST RECORD
   80 IF(ICHSC-IGVB(ICOM1,0,11))20,79,78
   78 ICOM1=IPVB(ICHSC,ICOM1,0,11)
   79 IF(ICHWD-IADD)81,85,85
   81 ICOM1=IPVB(ICHWD+INSIZ/20,ICOM1,12,15)
      GO TO 86
   85 ICOM1=IPVB(ICHWD-IADD,ICOM1,12,15)
      ICOM1=IPVB(ICHSC+1,ICOM1,0,11)
   86 GO TO(20,82),IFLG
C       FILL IN FREE AREA CHAIN IF THIS WAS NOT FIRST ONE
   82 CALL RMASR(ISVSC,ISVWD)
      GO TO (84,83),IERFL
   83 IERFL=1
      GO TO 20
   84 IS9=LSTSP
      IS10=LSTWP
      CALL WMASR(ISVSW,0)
      GO TO 20
 1000 CALL ERR IERR
      IERFL=1
```

```
999 CONTINUE
    WRITE 4 1 COMM
    ENSTF=IGVB(ICOM1,0,11)
    NSLFT=SZSTU-ENSTF-1
    WRITE(1,900)NSLFT
900 FORMAT('THERE ARE NOW ', I4, ' SECTORS LEFT IN STU. FILE')
    CALL LINK  EXEC
    END
```

```
** ADVBL

      INTEGER COMM(165),BUFF(41),        STURC(340),FLPTR(4),CSPTR(4),
     +        CHAR(40),MPT(30)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (IDIV2,COMM(7)),(IDIV1,COMM(24)),(NCRD,COMM(34)),
     +           (KECD,BUFF(41)),(ICM16,COMM(16)),(ICM15,COMM(15)),
     +            (ICM19,COMM(19)),(ICM20,COMM(20)),(ICM21,COMM(21)),
     +            (ICM6,COMM(6)),(ID1,BUFF(1)),(ID2,BUFF(2)),
     +            (ID3,BUFF(3)),(STURC(1),IST),
     +            (CHAR(1),COMM(126)),(ICM14,COMM(14))
      EQUIVALENCE (KD,BUFF(5)),(KN,BUFF(6)),(KS,BUFF(7))
      EQUIVALENCE (KID,BUFF(4))
      EQUIVALENCE (LSTPT,CSPTR(1)),(IDP,CSPTR(2)),(ICN,CSPTR(3)),
     +            (ISEC,CSPTR(4)),(KVAIL,COMM(37))
      DATA M,MM,MMM/3*0/,KAST/'*'/
      DEFINE FILE 5(1024,5,U,N5),9(50,4,U,N9),2(300,12,U,N2)
      DEFINE FILE 1(8160,20,U,N1),4(320,1,U,N4),8(96,10,U,N8),
     +           3(800,30,U,N3)
C...ADDS A NEW GROUP TO END OF MASTER RECORD
C...BUFF(1),(2),(3) ARE ID FIELDS
C...BUFF(4)-(ICM21) ARE FIELDS TO PUT INTO RECORD
      IFLG=1
C...IT IS UP TO RVBLC TO SET BUFF WITH FIELD DATA AND SET COMM(6)
    1 CALL RVBLC
      IF(KECD-KAST)4,22,4
    4 IF(ID1-M)20,5,20
    5 IF(ID2-MM)20,10,20
   10 IF(ID3-MMM)20,35,20
   20 M=ID1
      MM=ID2
      MMM=ID3
   22 GO TO(30,25),IFLG
C...PUT PREVIOUS RECORD BACK
   25 CALL IPFLD NCFLD,X,4
      CALL WMASR(ISCWD,0)
      IFLG=1
   30 IF(KECD-KAST)32,999,32
C...FIND NEW RECORD
   32 CALL HSHF2(ID1,ID2,ID3,K,IDIV2,2,ISCWD)
      IF(K)33,33,34
   33 CALL ERR(8)
      WRITE(1,900)ID1,ID2,ID3
  900 FORMAT('REC. ID IS ',3I3)
      GO TO 135
   34 CALL RMASR(ISCWD)
C...COMPUTE SPACE AVAILABLE FOR FIELD GROUPS
C...ADD NO. WORDS IN MAND., OPT., VBL FIELD.
C...PLUS NO. OF VBL BLOCK GROUPS TIMES WORDS PER GROUP.
      NCFLD=GFLD(4)
      LVBL=GFLD(2)
      IP=IGVB(IST,0,0)
   36 LNGTH=GFLD(3)
   35 CONTINUE
C...COMPUTE CURRENT EFFECTIVE LENGTH OF RECORD.  SEE IF THERE
C...IS ROOM FOR ONE MORE DESCRIPTOR GROUP
      LS=ICM14+ICM15*IP+LVBL+NCFLD*ICM16
      IF(LNGTH-LS-ICM16)40,50,50
C...NEED MORE SPACE
   40 CALL IPFLD NCFLD,X,4
      CALL RECMV(ISCWD,K)
      GO TO(36,45),IERFL
   45 CALL ERR(23)
      IERFL=1
      IFLG=1
      GO TO 1
C...COMPUTE FIELD NOS. FOR GROUP
   50 NF=ICM19+ICM20+1+ICM21*NCFLD
C...FILL IN DESCRIPTION INVERTED LIST IF ICOM6=2
      GO TO(90,65),ICM6
C...ID OF DESCRIPTOR IN BUFF(4)=KID
```

```
 65 CONTINUE
    KEY=2
 66 CALL HSHF1(KID,IR,IDIV1,KEY,CSPTR)
    IF(IR)134,134,80
134 CALL ERR(7)
135 CALL STACK
    M=0
    GO TO 1
 80 CALL INVRT(3,LSTPT,30,0,ISCWD,MPT)
    READ(3'IR)KID,IPNT,I1,I2,I3
    N=IGVB(I3,8,15)
    I3=IPVB(N+1,I3,8,15)
    WRITE(3'IR)KID,IPNT,I1,I2,I3
    GO TO(90,134),IERFL
 90 IFLG=2
    NOFLD=NOFLD+1
    IERFL=1
    DO 95 I=1,ICM21
    CALL IPFLD(BUFF(I+4),X,NF+I)
    GO TO(95,91),IERFL
 91 IERFL=1
    WRITE(5,960)I
960 FORMAT('ERR ON ',I4)
 95 CONTINUE
    GO TO 1
999 WRITE(4'1)COMM
    CALL LINK(EXEC)
    END
```

```
** GPDRP

      INTEGER DEP,CRS,SEC,        STURC(340),     CRINX(497)
      INTEGER COMM(165),BUFF(41),FLPTR(4),MPT(30)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (ICM19,COMM(19)),(ICM20,COMM(20)),(ICM21,COMM(21)),
     +            (ICLCH,COMM(6)),(KDAT,COMM(36)),(ICM14,COMM(14)),
     +            (ICM15,COMM(15)),(ICM16,COMM(16)),(IDIV1,COMM(7)),
     +           (IDIV2,COMM(24)),(NCRD,COMM(34)),(NPRNT,COMM(35))
      DATA KAST/'*'/
      DEFINE FILE 1(8160,20,U,N1),2(300,12,U,N2),3(800,30,U,N3),
     *            5(1024,5,U,N5),8(96,10,U,N8)
C...THIS DROPS A GROUP FROM THE BLOCK AT THE END OF A MASTER RECORD
      DO 5 I=1,497
    5 READ(3'I)CRINX(I)
      MOVFL=ICM19+ICM20+1
C...ID AND NAME CARD FOLLOWED BY SOME DROP CARDS
   10 READ(NCRD ,900)M,N,NN,DEP,CRS,SEC,KST
  900 FORMAT(2I3,T78,I1,T28,I2,T35,I3,A1,T80,A1)
   15 IF(KST-KAST)18,999,18
   18 IF(M)26,26,20
   20 CALL HSHF2(M,N,NN,KREC,IDIV1,2,NSNW)
      IF(KREC)21,25,25
   21 CALL ERR (7)
   23 READ(NCRD,900)M,N,NN,DEP,CRS,SEC,KST
      IF(M)24,24,15
   24 CALL STACK
      GO TO 23
   25 CALL RMASR(NSNW)
      GO TO 10
   26 NGPS= GFLD(4)
C...COMPUTE FIELD NO. OF FIRST FIELD IN LAST GROUP
      NFLDS=(NGPS-1)*ICM21+1
      LFLD=NFLDS+MOVFL
      NLFLD=LFLD-ICM21
   30 IG=GFLD(LFLD)
      IF(DEP-IG)35,31,35
   31 IG=GFLD(LFLD+1)
      IF(CRS-IG)35,32,35
   32 IG=GFLD(LFLD+2)
      IG=IPVB(IG,64,0,7)
      IF(SEC-IG)35,42,35
C...DROP BACK ONE GROUP AND TRY AGAIN
   35 LFLD=LFLD-ICM21
      IF(LFLD-MOVFL)36,36,30
   36 CALL ERR(28)
   37 CALL STACK
      IERFL=1
      GO TO 10
C...MAKE SURE THIS IS NOT A COURSE IN PREVIOUS QUARTER
C...TAKE THIS OUT IF DATE CHECKING ISN'T NEEDED
   42 IG=GFLD(LFLD+5)
      IF(IG-KDAT)47,50,47
   47 CALL ERR(63)
      GO TO 37
   50 CONTINUE
C...RESET NO. OF GROUPS IN VBL BLOCK
   55 CALL IPFLD(NGPS-1,X,4)
C...COMPUTE WORD POINTERS FOR REPACKING COURSES
      IG=GFLD(2)
      NWRDS=ICM14+IGVB(STURC(1),0,0)*ICM15+IG
C...COMPUTE WHICH VBL GROUP IS DROPPED
      LFLD=(LFLD-MOVFL)/ICM21
C...COMPUTE WORD POINTER TO IT AND TO END GROUP
      N1=NWRDS+LFLD*ICM16+1
      N2=N1+(NGPS-LFLD-1)*ICM16-1
      DO 58 I=N1,N2
      II=I+ICM16
   58 STURC(I)=STURC(II)
      CALL WMASR(NSNW,0)
      GO TO(10,59),ICLCH
```

```
   59 KID=IPVB(DEP,CRS,0,5)+SEC
      KEY=2
   69 CALL HASH1(KID,CRINX,IR,IDIV2,KEY)
      IF(IR)158,158,159
  158 CALL ERR(10)
      GO TO 37
  159 READ(3*IR)KID,IPNT,I1,I2,I3
C...REDUCE NO. ENROLLED BY ONE
      N=IGVB(I3,8,15)
      I3=IPVB(N-1,I3,8,15)
      WRITE(3*IR)KID,IPNT,I1,I2,I3
      CALL INVRT(3,IPNT,497,NSNW,0,MPT)
C...INVRT WILL FIND THE FIRST OCCURRENCE OF NSNW IN THE
C...INVERTED LIST AND REPLACE IT WITH 0
      GO TO(10,37),IERFL
  999 CALL LINK(EXEC)
      END
```

```
**DRCP

      INTEGER COMM(165),FLPTR(4),STURC(340)
      INTEGER   DCLSL,MPT(30),BUFF(41)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (KARD,COMM(34)),(IDIV1,COMM(7)),(IDIV2,COMM(24))
      EQUIVALENCE (COMM(28),ICM28),(COMM(6),ICM6)
      EQUIVALENCE (KDAT,COMM(36)),(COMM(4),ICM4),(COMM(2),ICM2)
      EQUIVALENCE                 (IS8,STURC(8)),(IS9,STURC(9))
      EQUIVALENCE (COMM(19),ICM19),(COMM(20),ICM20),(COMM(21),ICM21)
      DATA DCLSL/'$/'/
      DATA NEG,IZ/-1,0/
      DEFINE FILE 1(8160,20,U,N1),2(300,12,U,N2),3(800,30,U,N3),
     +            5(1024,5,U,N5),4(320,1,U,N4),8(96,10,U,N8)
C...THIS ERASES A MASTER RECORD FROM THE DATA BASE
C...INPUT CARD ONLY NEEDS THE ID NO. OF THE RECORD
      KEY=2
    1 READ(KARD,900)M,N
  900 FORMAT(2I3)
      IF(M)999,999,10
   10 CALL HSHF2(M,N,0,IR,IDIV1,KEY,ISCWD)
      ISVSW=ISCWD
      WRITE(5'IR)NEG,IZ,IZ,IZ,IZ
      CALL RMASR(ISCWD)
      IF(ICM28)20,20,15
   15 K=GFLD(ICM28)
      CALL INVRT(2,K,12,ISCW,0,MPT)
      GO TO(20,16),IERFL
   16 IERFL=1
      CALL STACK
   20 GO TO(50,25),ICM6
   25 NGPS=GFLD(4)
      IF(NGPS)50,50,30
   30 MOVFL=ICM19+ICM20+1
      NFELD=MOVFL-1+ICM21*NGPS
C...NFELD SHOULD POINT AT DATE FIELD OF LAST GROUP
   32 IDAT=GFLD(NFELD)
      IF(KDAT-IDAT)50,35,50
   35 KD=GFLD(NFELD-5)
      KN=GFLD(NFELD-4)
      KS=GFLD(NFELD-3)
      KR=IPVB(KD,KN,0,5)+IGVB(KS,0,7)
      CALL HSHF1(KR,IR,IDIV2,KEY,IPTR)
      IF(IR)50,50,40
   40 CALL INVRT(3,IR,30,ISCW,0,MPT)
      GO TO(45,41),IERFL
   41 IERFL=1
      CALL STACK
   45 NFELD=NFELD-ICM21
      IF(NFELD-MOVFL)32,32,50
   50 CONTINUE
C...ENTER RECORD AREA IN FREE AREA CHAIN
      NSW=ICM2
      ICM2=ISCWD
      K=GFLD(3)
      DO 60 I=1,K
   60 STURC(I)=DCLSL
      IS8=K
      IS9=NSW
      CALL WMASR(ISVSW,0)
C...REDUCE COUNT OF NO. OF MASTER RECORDS
      ICM4=ICM4-1
      GO TO 1
  999 WRITE(4'1)COMM
      CALL LINK(EXEC)
      END
```

```
** GARBG

      INTEGER FREC(340),FLPTR(4),S(320)
      INTEGER COMM(165),STURC(340),BUFF(41),MVINX(2),DOLSL,ST4,
     +        CRS(30),STX(5),IFREX(2,400),ST8,ST9
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (STURC(8),ST8),(STURC(9),ST9)
      EQUIVALENCE (KSIZE,COMM(3)),(S(1),IFREX(1,1))
      EQUIVALENCE (MVINX(1),MV1),(MVINX(2),MV2),(STX(4),ST4),
     +            (FLPTR(1),IF1),(FLPTR(2),KSC1),(FLPTR(3),IF2),
     +            (FLPTR(4),KSC2),(COMM(1),ICM1),(COMM(7),ICM7)
      EQUIVALENCE (CRS(1),STURC(1)),(STX(1),FREC(1)),(IDIV,COMM(8))
      EQUIVALENCE (ICM6,COMM(6)),(ICM15,COMM(15)),(ICM14,COMM(14)),
     +            (ICM16,COMM(16)),(ICM36,COMM(36)),(ICM2,COMM(2))
      DATA DOLSL/'$'/
      DEFINE FILE 1(8160,20,U,N1),2(300,12,U,N2),3(800,30,U,N3),
     +  4(320,1,U,N4),5(1024,5,U,N5),9(640,2,U,N9),8(96,10,U,N8)
C...THIS COMPRESSES THE FILE SO THAT THERE ARE NO FREE AREAS EMBEDDED
C...IN THE MASS OF RECORDS. THERE WILL JUST BE AT
C...IN THE MASS OF RECORDS. THERE WILL JUST BE THE ACTIVE AREA AND END
C...OF FILE FREE AREA.
C...IFREX IS DIMENSIONED (2,400) SO THAT EXPANDING OR CONTRACTING IT
C...WONT AFFECT SHLL2
C...  FILE 9 IS TEMPORARY WS FILE FOR MOVE INDEX. REQUIRES 4 SECTORS
C...FOR 800-880 STUDENTS
      DO 5 I=1,2
      DO 5 J=1,400
    5 IFREX(I,J)=0
C...  INITIALIZE MOVE INDEX
      DO 10 I=1,500,160
   10 WRITE(9'I)S
      IP=1
      ISVLS=IGVB(ICM1,0,11)
      IFREX(1,1)=ISVLS
      IFREX(2,1)=IGVB(ICM1,12,15)
      NFS=IGVB(ICM2,0,11)
      NFW=IGVB(ICM2,12,15)
      NFSW=ICM2
      KNFRE=1
      DO 7 K=2,400
      IF(NFSW)1998,8,1998
 1998 KNFRE=KNFRE+1
      CALL RMASR(NFSW)
      GO TO(11,2001),IERFL
 2001 IERR=42
      GO TO 999
   11 IFREX(1,K)=NFS
      IFREX(2,K)=NFW
C...GET POINTER TO NEXT FREE AREA
      NFSW= ST9
      NFS=IGVB(NFSW,0,11)
      NFW=IGVB(NFSW,12,15)
    7 CONTINUE
C...SORT IFREX INTO ASCENDING ORDER
    8 CALL SHLL2(IFREX,KNFRE)
      NFS=IFREX(1,IP)
      NFW=IFREX(2,IP)
      NFSW=IPVB(NFS,NFW,0,11)
      IP=IP+1
C...READ FIRST FILL AREA
      CALL RMASR(NFSW)
      NXFS=IFREX(1,IP)
      NXFW=IFREX(2,IP)
      NXFSW=IPVB(NXFS,NXFW,0,11)
      IP=IP+1
      NWRDS=ST8
      KNFRE=KNFRE-1
C     IF THIS FREE AREA GOES TO END OF FILE NOTHING MORE TO BE DONE
      IF(KNFRE)355,355,9
C...CALCULATE NEXT STDNT PNTR
    9 CALL PTCAL(NFSW,NWRDS,NSTSW)
```

```
      NSTSC=IGVB(NSTSW,0,11)
      NSTWD=IGVB(NSTSW,12,15)
   14 CONTINUE
C...READ NEXT MASTER RECORD
   20 CALL DRIVE(NSTSC,NSTWD)
      NSTW=NSTWD*20
      IRN=320-NSTW
      READ(IF1'KSC1)(FREC(I),I=1,IRN)
      IRN=IRN+1
      READ(IF2'KSC2)(FREC(I),I=IRN,340)
C...EXTRACT NO. OF WORDS IN RECORD
      KWD=IGVB(FREC(1),15,15)*256+IGVB(FREC(2),0,7)
      DO 50 I=1,KWD
   50 STORC(I)=FREC(I)
      MV1=NSTSW
      MV2=NFSW
C...MVINX CONTAINS OLD POINTER IN POSITION 1, NEW PTR IN POS. 2
C     FOR FIND MVINX CONTAINS OLD POINTER, RETURNS NEW PTR
C     FOR PLACE MVINX CONTAINS OLD AND NEW POINTERS
C     KEY=1 OR 2 FOR PLACE OR FIND
C     IDIV MUST BE PRIME AND SET FROM COMM
      KEY=1
      CALL HSHIX(MVINX,IDIV,KEY)
C     WRITE STUDENT BACK ON DISK
      CALL WMASR(NFSW,0)
C     SAVE POINTER AND SIZE OF STUDENT FOR USE AT STMNT 100
      LSC=NFS
      LSW=NFW
      NNN=KWD
C     CALCULATE POINTER FOR FILL AREA
      CALL PTCAL(NFSW,KWD,NFSW)
      NFS=IGVB(NFSW,0,11)
      NFW=IGVB(NFSW,12,15)
C     CALCULATE POINTER TO NEXT STUDENT TO MOVE
   66 CALL PTCAL(NSTSW,KWD,NSTSW)
      NSTSC=IGVB(NSTSW,0,11)
      NSTWD=IGVB(NSTSW,12,15)
C     CHECK TO SEE IF WE ARE UP TO NEXT FREE AREA
      IF(NSTSC-NXFS)14,70,75
   70 IF(NSTWD-NXFW)14,75,75
C.....RECALCULATE POINTER TO NEXT MAS.REC. FIRST EXAMINE THIS FREE AREA
   75 CALL RMASR(NXFSW)
      KNFRE=KNFRE-1
      IF(KNFRE)100,100,76
   76 KWD=ST8
      NXFS=IFREX(1,IP)
      NXFW=IFREX(2,IP)
      NXFSW=IPVB(NXFS,NXFW,0,11)
      IP=IP+1
      GO TO 66
C.....PATCH COMM POINTERS. FIRST CALCULATE END OF STUDENT RECS.
  100 LSCWD=IPVB(LSC,LSW,0,11)
      CALL PTCAL(LSCWD,NNN,LSCWD)
      ICM1=LSCWD
      ICM2=0
C.....INITIALIZE FREE AREA
      CALL RMASR(ICM1)
      LSC=IGVB(LSCWD,0,11)
      LSW=IGVB(LSCWD,12,15)
      DO 110 I=1,340
  110 STORC(I)=DCLSL
      IF(LSC-KSIZE+100)120,120,115
  115 ST8=320*(KSIZE-LSC)-LSW+1
      GO TO 121
  120 ST8=32000
  121 ST9=0
      CALL WMASR(ICM1,0)
      DO 130 I=8,10
  130 STORC(I)=DCLSL
      J=LSC+1
      KS=KSIZE-1
      DO 150 K=J,KS
```

```
      IF(K-ISVLS)150,150,160
  150 CALL WMASR(K,320)
C...NOW UPDATE POINTERS IN CATEGORY FILE
  160 DO 210 I=101,300
      READ(2'I)(BUFF(J),J=1,12)
      DO 208 J=2,12
      IF(BUFF(J))208,208,205
  205 CONTINUE
      MV1=BUFF(J)
      KEY=2
      CALL HSHIX(MVINX,IDIV,KEY)
      BUFF(J)=MV2
  208 CONTINUE
      WRITE(2'I)(BUFF(J),J=1,12)
  210 CONTINUE
C...UPDATE COURSE POINTERS IF NEC.
      GO TO(300,255),ICM6
  255 DO 280 I=500,800
      READ(3'I)CRS
      DO 270 J=2,30
      IF(CRS(J))270,270,260
  260 MV1=CRS(J)
      KEY=2
      CALL HSHIX(MVINX,IDIV,KEY)
      IF(KEY)265,265,267
  265 CRS(J)=0
      GO TO 270
  267 CRS(J)=MV2
  270 CONTINUE
      WRITE(3'I)CRS
C.....FINALLY, UPDATE THE STUDENT INDEX
  280 CONTINUE
  300 DO 350 I=1,ICM7
      READ(5'I)STX
      IF(ST4)350,350,310
  310 MV1=ST4
      KEY=2
      CALL HSHIX(MVINX,IDIV,KEY)
      ST4=MV2
      WRITE(5'I)STX
  350 CONTINUE
  355 NSLFT=KSIZE-IGVB(ICM1,0,11)
      WRITE(1,900)NSLFT
  900 FORMAT('THERE ARE NOW',I4,'SECTORS FREE IN STU. FILE')
      WRITE(4'1)CCMM
   99 CALL LINK (EXEC)
  999 CALL ERR(IERR)
      IERFL=1
      GO TO 99
      END
```

```
**QUERY

      INTEGER C12
      INTEGER LANG(6),SPTR,OP(4),CRIT(12),IVAL(50),COMM(165),STURC(340),
     + FLPTR(4),ICP(4)
      COMMON COMM,FLPTR,STURC,IERFL,OP,CRIT,IVAL,SPTR
      EQUIVALENCE (CRIT(12),C12)
      DATA ICP/'+','-','*','/'/
      DATA LANG/'SE','RE','LI','AR','ST','EX'/
C...THIS LINKS TO OR CALLS THE ROUTINES WHICH PERFORM THE INQUIRY OPER.
C...QUERY COMMANDS CONSIST OF SELECT,REFINE,LIST,ARRANGE,STATS,EXIT
      DEFINE FILE 1(8160,20,U,N1),5(1024,5,U,N5),4(320,1,U,N4),
     +            9(960,1,U,N9),8(96,10,U,N8)
C...FILE 9 IS TEMPORARY FOR WORKING SET
      DO  2000 I=1,4
 2000 OP(I)=ICP(I)
    1 WRITE(1,900)
  900 FORMAT('SELECT,REFINE,LIST,ARRANGE,STATS,OR EXIT')
      READ(6,901)KL
  901 FORMAT(A2)
      DO 10 I=1,6
      IF(KL-LANG(I))10,15,10
   10 CONTINUE
   15 GO TO(100,200,300,400,500,600,1),I
  100 C12=1
      SPTR=0
      CALL LINK(SLECT)
  200 C12=2
      CALL LINK(SLECT)
  300 CALL LISTM
      GO TO 1
  400 CALL ARRNG
      GO TO 1
  500 CALL STATS
      GO TO 1
  600 CALL LINK(EXEC)
      END
```

```
**SLECT

      REAL VAL(25)
      INTEGER CCLSL,CP2,SZMAS,C12
      INTEGER COMM(165),FLPTR(4),STURC(340)
      INTEGER CRIT(12),NOT(3),AND(3),OR1,OR2,REL(2,6),RPAR,PER,SEMI,
     +        LINE(78),BLANK,STATE,QUOTE,OP(4),CRITP,TCRIT,VPTR,XP(25),
     +        TXP(25),IVAL(50),XPPTR,SPTR
      COMMON COMM,FLPTR,STURC,IERFL,OP,CRIT,IVAL,SPTR
      EQUIVALENCE (COMM(19),ICM19),(COMM(20),ICM20),(COMM(3),SZMAS)
      EQUIVALENCE(VAL(1),IVAL(2)),(BLANK,COMM(132)),(PER,COMM(164)),
     +            (CR1,COMM(129)),(OR2,COMM(135)),(STURC(1),IST)
      EQUIVALENCE (CP(2),CP2),(CRIT(12),C12),(XP(1),IXP1),(IS8,STURC(8))
      DATA CCLSL/'$'/,IZ/0/
      DATA REL/'L','T','L','E','E','Q','G','E','G','T','E','X'/,
     +     NOT/'N','O','T'/,AND/'A','N','D'/
      DATA RPAR,LPAR,SEMI,QUOTE/')','(',';',''''/
      DEFINE FILE 1(8160,20,U,N1),5(1024,5,U,N5),4(320,1,U,N4),
     +            9(960,1,U,N9),8(96,10,U,N8)
C...THIS GETS AND ENCODES THE SELECTION CRITERIA, AND THEN SELECTS
C...THOSE RECORDS WHICH SATISFY THE CRITERIA.  THE POINTERS TO THE
C...SELECTED RECORDS ARE SAVED IN THE WORK FILE. SPTR IS COUNT OF SELECT
C...C12 USED TO INDICATE SELECT OR REFINE
    3 XPPTR=2
      IXP1=0
      VPTR=1
      CRITP=1
      STATE=1
      MOVFL=ICM19+ICM20+1
      CALL ERR(34)
      READ(6,901)LINE
  901 FORMAT(78A1)
C...FIRST, PROCESS INPUT
      DO 1000 I=1,78
      IF(LINE(I)-BLANK)4,1000,4
    4 IF(LINE(I)-SEMI)5,1001,5
    5 GO TO(10,40,80,50),STATE
C...LOOK FOR FIELD. NF LE 0 MEANS ERROR
C...ON RETURN I POINTS TO LAST CHAR. OF FIELD
   10 CALL FIELD(LINE,I,NF)
      IF(NF)20,20,12
   12 TCRIT=IPV8(NF,TCRIT,0,5)
      XP(XPPTR)=CRITP
      XPPTR=XPPTR+1
      STATE=2
      GO TO 1000
C...LOOK FOR LEFT PAREN.
   20 IF(LINE(I)-LPAR)30,21,30
   21 KODE=0
      GO TO 300
C...IS IT NOT
   30 II=I-1
      DO 35 J=1,3
      II=II+1
      IF(LINE(II)-NOT(J))1050,35,1050
   35 CONTINUE
      KODE=-4
      I=I+2
      GO TO 300
C...LOOK FOR RELATION
   40 DO 45 J=1,6
      IF(LINE(I)-REL(1,J))45,41,45
   41 IF(LINE(I+1)-REL(2,J))45,46,45
   45 CONTINUE
      GO TO 1050
   46 TCRIT=IPV8(J,TCRIT,6,8)
      I=I+1
      STATE=3
      IF(J-6)1000,200,1000
C...LOOK FOR RT. PAREN.
   50 IF(LINE(I)-RPAR)60,55,60
```

```
   55 KODE=-1
      GO TO 300
C...LOOK FOR AND
   60 II=I-1
      DO 65 J=1,3
      II=II+1
      IF(LINE(II)-AND(J))70,65,70
   65 CONTINUE
      KODE=-2
      STATE=1
      I=I+2
      GO TO 300
C...LOOK FOR CR
   70 IF(LINE(I)-CR1)1050,72,1050
   72 IF(LINE(I+1)-CR2)1050,73,1050
   73 KODE=-3
      I=I+1
      STATE=1
      GO TO 300
C...LOOK FOR COMPARISON VALUE.  IF FIELD EXPRESSION IT MUST
C...BE ENCLOSED IN PARENTHESES.
   80 IF(LINE(I)-LPAR)81,100,81
   81 IF(LINE(I)-QUOTE)85,150,85
C...SHOULD BE NUMBER
   85 CALL NUMBR(LINE,I,X,ITYP)
C...NUMBR ANALYZES CHARACTERS IN LINE UP TO THE NEXT NON-NUMERIC
C...CHARACTER. BLANKS ARE IGNORED. NUMERIC VALUE IS RETURNED IN X.
C...I RETURNS AS POINTER TO LAST CHAR. OF NUMBER.
C...ITYP IS 0 FOR INTEGER,1 FOR REAL. 2 FOR ERROR.
      IF(ITYP-2)86,1050,1050
C...PUT TYPE AND VALUE POINTER IN CRITERIA
   86 TCRIT=IPVB(ITYP,TCRIT,9,10)
      TCRIT=IPVB(VPTR,TCRIT,11,15)
      VPTR=(VPTR+2)/2
      VAL(VPTR)=X
      VPTR=2*VPTR+1
      GO TO 200
C...TRANSLATE FIELD EXPRESSION. KOP INITIALLY INDICATES PLUS
  100 I=I+1
      KOP=1
      TCRIT=IPVB(2,TCRIT,9,10)
      TCRIT=IPVB(VPTR,TCRIT,11,15)
      IF(LINE(I)-CP2)107,105,107
C...KOP INDICATES MINUS SIGN
  105 KOP=2
      I=I+1
  107 CALL NUMBR(LINE,I,X,ITYP)
      IF(ITYP-2)110,120,120
C...NEGATING KOP INDICATES NUMERIC VALUE WILL FOLLOW IT
  110 KOP=-KOP
      IVAL(VPTR)=KOP
      VPTR=VPTR+4
      IP=VPTR/2
      VAL(IP)=X
      GO TO 130
C...BETTER BE FIELD
  120 CALL FIELD(LINE,I,NF)
      IF(NF)1050,1050,125
  125 IVAL(VPTR)=KOP
      IVAL(VPTR+1)=NF
      VPTR=VPTR+2
C...LOOK FOR RT. PAREN.
  130 I=I+1
      IF(LINE(I)-RPAR)135,140,135
C...CHECK FOR OPERATION
  135 DO 136 KOP=1,4
      IF(LINE(I)-OP(KOP))136,107,136
  136 CONTINUE
      GO TO 1050
  140 IVAL(VPTR)=0
      VPTR=VPTR+1
      GO TO 200
```

```
C...ENTER STRING
  150 TCRIT=IPVB(3,TCRIT,9,10)
      TCRIT=IPVB(VPTR,TCRIT,11,15)
      KNT=0
  153 I=I+1
      IF(LINE(I)-CUCTE)155,160,155
  155 KNT=KNT+1
      IVP=VPTR+KNT
      IVAL(IVP)=LINE(I)
      GO TO 153
  160 IVAL(VPTR)=KNT
      VPTR=VPTR+KNT+1
C...ENTER TCRIT IN CRIT
  200 CRIT(CRITP)=TCRIT
      CRITP=CRITP+1
      STATE=4
      GO TO 1000
C...ENTER KODE IN XP
  300 XP(XPPTR)=KODE
      XPPTR=XPPTR+1
 1000 CONTINUE
C...NOW SORT XP INTO POLISH.  FIRST PUT END PAREN.
 1001 XP(XPPTR)=-1
 1155 KL=0
      IFLG=1
      IFLAG=1
      DO 1200 I=1,XPPTR
      IF(XP(I))1165,1160,1165
 1160 GO TO(1161,1162),IFLG
 1161 IFLG=2
      IFLAG=2
      J=I
 1162 KL=KL+1
      GO TO 1200
 1165 GO TO(1200,1170),IFLG
 1170 IF(XP(I)+1)1200,1175,1200
 1175 KL=KL-1
      IF(KL)1200,1180,1200
 1180 CALL POLST(XP,J+1,I-1,TXP)
      KL=0
      IFLG=1
      XP(J)=-99
      XP(I)=-99
 1200 CONTINUE
      GO TO(1203,1155),IFLAG
 1203 CONTINUE
C...NOW START READING RECORDS AND EVALUATING
      IS=0
      GO TO (1204,2000),C12
 2000 IS=IS+1
      IF(IS-SPTR)2001,2001,1600
 2001 CALL IRTRV(ISCWD,IS,2)
      ISC=IGVB(ISCWD,0,11)
      ISW=IGVB(ISCWD,12,15)
      GO TO 1205
C...POINTER FOR SECTOR 1, WORD BLOCK 0
 1204 ISCWD=16
 1205 CALL RMASR(ISCWD)
      IF(STORC(1)-DOLSL)1220,1208,1220
 1208 L=STORC(8)
C...ASSUMPTION IS MADE HERE THAT IF POINTER IS IN WORKING
C...SET IT WILL NOT GET INTO FREE AREA
 1210 CALL PTCAL(ISCWD,L,ISCWD)
      IF(IGVB(ISCWD,0,11)-SZMAS)1205,1600,1600
C...SEE IF THIS RECORD SATISFIES CRIT.
C...FIRST, SET TXP TO ZERO
 1220 DO 1225 I=1,25
 1225 TXP(I)=0
      K=0
      XP(XPPTR)=-98
      DO 1400 I=1,XPPTR
      IF(XP(I))1235,1235,1230
```

```
 1230 K=K+1
      TXP(K)=XP(I)
      GO TO 1400
 1235 IF(XP(I)+99)1400,1400,1240
 1240 ICP=-XP(I)-1
C...EVALUATE EACH CRITERION
      IF(TXP(K)-100)1260,1250,1252
 1250 I1=0
      GO TO 1261
 1252 I1=1
      GO TO 1261
 1260 I1=IRLVL(TXP(K))
C...TAKE CARE OF NOT OPERATION
 1261 IF(ICP-3)1262,1290,1262
 1290 IF(I1)1320,1320,1330
 1262 K=K-1
      IF(K)1266,1266,1263
 1266 TXP(1)=IRLVL(TXP(1))
      GO TO 1401
 1263 IF(TXP(K)-100)1270,1264,1265
 1264 I2=0
      GO TO 1275
 1265 I2=1
      GO TO 1275
 1270 I2=IRLVL(TXP(K))
 1275 GO TO(1280,1300),ICP
 1280 TXP(K)=I1*I2+100
      GO TO 1400
 1300 IF(I1)1310,1310,1320
 1310 IF(I2)1330,1330,1320
 1320 TXP(K)=101
      GO TO 1400
 1330 TXP(K)=100
 1400 CONTINUE
 1401 IF(TXP(1))1495,1495,1450
 1450 GO TO(1455,2000),C12
C...SPTR IS INITIALIZED TO 0 IN QUERY PRIOR TO SLECT LINK
 1455 SPTR=SPTR+1
      CALL IRTRV(ISCWD,SPTR,1)
 1495 GO TO(1500,1496),C12
 1496 CALL IRTRV(IZ,IS,1)
      GO TO 2000
 1500 L=GFLD(3)
      GO TO(1210,2000),C12
 1600 CALL IRTRV(ISCWD,I,3)
      GO TO(1602,1601),C12
C...ELIMINATE ZEROED POINTERS.  MAKES IT BETTER FOR ARRNG.
 1601 DO 1700 I=1,SPTR
      CALL IRTRV(ISCWD,I,2)
      IF(ISCWD)1700,1610,1700
 1610 JJ=I+1
      ICNT=1
      DO 1650 J=JJ,SPTR
      IF(ISCWD)1660,1620,1660
 1620 ICNT=ICNT+1
 1650 CONTINUE
C...THERE ARE ICNT ZEROED POINTERS IN A ROW
 1660 JJ=I+ICNT
      DO 1670 J=JJ,SPTR
      CALL IRTRV(ISCWD,J,2)
      CALL IRTRV(ISCWD,J-ICNT,1)
 1670 CONTINUE
      SPTR=SPTR-ICNT
 1700 CONTINUE
 1602 WRITE(1,903)SPTR
  903 FORMAT(1X,I5,' SELECTED')
 1605 CALL LINK(QUERY)
 1050 WRITE(1,902)I
  902 FORMAT('SYNTAX NEAR ',I2,'TH CHAR.')
      GO TO 1605
      END
```

```
**ARRNG

      SUBROUTINE ARRNG
      INTEGER SP,STACK(20,2)
      INTEGER LINE(20),COMM(165),FLPTR(4),STORC(340),OP(4),IVAL(50),
     +        SPTR,CRIT(12)
      COMMON COMM,FLPTR,STORC,IERFL,OP,CRIT,IVAL,SPTR
      EQUIVALENCE (COMM(163),KOMMA),(COMM(132),KBLNK),(COMM(141),IEFF)
      ICNT=0
C...MESSAGE ASKS FOR FIELDS ON WHICH TO SORT
C...FIELDS ARE TO BE ENTERED AS A SERIES OF FXXX'S, WITH OR W/O SEPARATION
      CALL ERR(61)
      READ(6,901)LINE
  901 FORMAT(20A1)
      DO 20 I=1,20
      LINEI=LINE(I)
C...IGNORE BLANKS OR COMMAS
      IF(LINEI-KBLNK)5,20,5
    5 IF(LINEI-KOMMA)10,20,10
   10 CALL FIELD(LINE,I,NF)
      IF(NF)12,12,13
   12 WRITE(1,902)I
  902 FORMAT('SYNTAX NEAR',I2,'CHAR.')
      GO TO 999
C...SAVE FIELD
   13 ICNT=ICNT+1
      LINE(ICNT)=NF
   20 CONTINUE
C...NOW BEGIN SORTING
      CRIT(1)=0
      CRIT(2)=0
      SP=0
      I=1
      L=SPTR
  500 CALL G(I,L,K,ICNT,LINE)
      I2=L-K-1
      I1=K-I-1
      IF(I1)640,640,600
  600 IF(I2)660,660,610
  610 SP=SP+1
      IF(I1-I2)630,620,620
  620 STACK(SP,1)=I
      STACK(SP,2)=K-1
      I=K+1
      GO TO 500
  630 STACK(SP,1)=K+1
      STACK(SP,2)=L
      L=K-1
      GO TO 500
  640 IF(I2)670,670,650
  650 I=K+1
      GO TO 500
  660 L=K-1
      GO TO 500
  670 IF(SP)680,680,690
  680 CALL IRTRV(K,K,3)
  999 CONTINUE
      WRITE(5,903)CRIT(1),CRIT(2)
  903 FORMAT(1X,2I8)
      RETURN
  690 I=STACK(SP,1)
      L=STACK(SP,2)
      SP=SP-1
      GO TO 500
      END
```

```
** MODFC

      INTEGER COMM(165),FLETR(4),STORC(340),ELFF(41)
      INTEGER FFL(64),F1(16),F2(16),F3(16),F4(16),ELF4,ELF5,ELF6,ELF7,
     +        ELF8,ELF9,ELF10,ELF11,FPT,XFT
      REAL XELFF(10)
      COMMON COMM, FLETR,STORC,IERFL,ELFF,XELFF
      DATA M,IFLAG/0,1/
      EQUIVALENCE (ELFF(1),ID1),(ELFF(2),ID2),(ELFF(3),ID3),
     +            (COMM(7),IDIV),(COMM(19),ICM19),(COMM(20),ICM20),
     +            (COMM(21),ICM21),(FFL(1),F1(1)),(FFL(17),F2(1)),
     +            (FFL(33),F3(1)),(FFL(49),F4(1))
C...MDMOD RETURNS ID IN ELFF(1)-ELFF(3).  ELFF(4) INDICATES MODIFICATION
C...TYPE 1,2,3,OR 4. THE BITS OF ELFF(5)-ELFF(8) INDICATE WHICH FIELDS
C...TO MODIFY.  THE FIELD VALUES ARE GIVEN IN ELFF(9)-(40).
C...FLOATING PT. VALUES ARE IN XELFF(1)-(10)
C...MODIFICATIONS IN ANY ONE CYCLE CAN BE
C...1) CHANGE UP TO 32 FIELDS IN MAND. OR OPT. BLOCKS
C...2) CHANGE ANY 1 VAR. SUBFIELD. SUBFIELD NO. AND CHAR COUNT GIVEN IN
C...    ELFF(9) & (10).  CHARS. PACKED IN A2 IN ELFF(11)--
C...3) CHANGE FIELDS IN ANY ONE GROUP
C...4) ADD OPTIONAL BLOCK OR CHANGE ALL OPT. BLOCK FIELDS.
      NOFL=ICM19+ICM20
   10 IERFL=1
      CALL MDMOD
      GO TO(12,999),IERFL
   12 GO TO(25,15),IFLAG
   15 IF(ID1-M)20,16,20
   16 IF(ID2-M)20,17,20
   17 IF(ID3-MM)20,45,20
C...RETURN LAST MASTER RECORD
   20 CALL MMASR(ISW,0)
   25 CALL MSRF2(ID1,ID2,ID3,KR,IDIV,2,ISW)
      IF(KR)30,30,40
   30 CALL STACK
      M=0
      GO TO 10
   40 CALL MMASR(ISW)
      GO TO(45,30)IERFL
C...SET FIELD FLAGS
   45 CALL EXPAN(ELF5,F1)
   45 CALL EXPAN(ELF6,F2)
   45 CALL EXPAN(ELF7,F3)
   45 CALL EXPAN(ELF8,F4)
      FPT=9
      XFT=1
      GO TO(48,100,65,200),ELF4
   48 DO 60 I=1,NOFL
      IF(FFL(I))60,60,50
   50 CALL IFFLD(ELFF(FPT),XELFF(XFT),I)
      GO TO(55,30),IERFL
C...CHECK TO SEE WHICH PTR TO INCREMENT
   55 K=I+50
      IF(COMM(K)-32)56,58,58
   56 FPT=FPT+1
      GO TO 60
   58 XFT=XFT+1
   60 CONTINUE
      GO TO 10
C...CHECK ON GROUP FIELDS.  CHANGES IN FIRST 3 FIELDS IN GROUP NOT
C...ALLOWED.  IN THIS CASE ELFF(9)-(11) SHOULD HAVE A DESCRIPTOR ID.
C...ELFF(12)-- WILL HAVE THE NEW FIELD VALUES.
   65 IGP=LOCGP(ELF5,ELF10,ELF11)
C...IGP POINTS TO FIRST FIELD OF GROUP WITH GIVEN ID
      IF(IGP)30,30,70
C...NG AND NGL ARE BASIC FIELD NOS. OF GROUPS STARTING WITH FOURTH FIELD
   70 NG=NOFL+4
      NGL=NOFL+ICM21
      L=3
      DO 80 I=NG,NGL
      IF(FFL(I))76,76,72
```

```
   72 K=ICF+L
      CALL IFFLC(ELFF(EFT),XELFF(XFT),K)
      K=MCFL+1+L
      IF(CCMM(K)-32)74,76,76
   74 EFT=EFT+1
      GC TC 78
   76 XFT=XFT+1
   78 L=L+1
   8C CCNTINLE
      GC TC 1C
C...FLT IN VEL SLEFIELC
  1CC CALL FVELF(ELF9,ELF1C,ELF11)
      GC TC(1C,11C,3C),IERFL
  11C CALL RECMV(ISW,KR)
      GC TC(111,3C),IERFL
  111 IERFL=1
      GC TC 1CC
  2CC CALL ZADCF
      GC TC(1C,21C),IERFL
  21C CALL RECMV(ISW,KR)
      GC TC(1CC,3C),IERFL
  9S9 WRITE(4*1)CCMM
      CALL LINK(EXEC)
      END
```

```
**UTLTY

      INTEGER COMM(165),STURC(340),BUFF(100),FLPTR(4)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      DEFINE FILE 1(8160,20,U,N1),2(300,12,U,N2),3(800,30,U,N3)
      DEFINE FILE 4(320,1,U,N4),5(1024,5,U,N5),8(96,10,U,N8)
      DEFINE FILE 6 42,15,U,N6 ,7 40,60,U,N7
      DEFINE FILE 9 50,4,U,N9
C...THIS CAN BE USED FOR A VARIETY OF UTILITY RECORD SEARCHING OR PATCHING
      WRITE(1,900)
  900 FORMAT('1-LIST CR PATCH COMM'/,'2-LIST ERR,ABBRV, OR ETC, FILES'/,
     +'3-LIST CR PATCH INDEX'/,'4-LIST OR PATCH CATEG, FILE'/,'5-LIST/PC
     +H MAS,REC,'/,'6-LIST CATEG, CHAIN'/,'7-LIST OR PATCH DESCRIPTOR'/,
     +'0-EXIT')
    2 READ(6,901)IGC
  901 FORMAT(I1)
      IF(IGC-8)4,2,2
    4 IF(IGC)99,99,5
    5 GO TO 10,20,30,40,50,60,70,99 ,IGO
   10 CALL LPCOM
      GO TO 1
   20 CALL LEARF
      GO TO 1
   30 CALL LPINX
      GO TO 1
   40 CALL  LPADV
      GO TO 1
   50 CALL LPMR
      GO TO 1
   60 CALL LADCH
      GO TO 1
   70 CALL LPCRS
    1 WRITE 1,902
  902 FORMAT  0,1,,,,CR 9
      GO TO 2
   99 CALL LINK(EXEC)
      END
```

The following main program is a special program used to print out a form of the student's transcript. The output includes a listing of what graduation requirements the student has not yet fulfilled.

```
** RQUIR

      INTEGER NAME(10),STURC(340),       SG(18),RQ(16),NAM1(21),
     +        CHAR(40),NAM2(15),COMM(165),DPNM(32,2),MPT(11)
      INTEGER BUFF(41),FLPTR(4)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE(MPT(1),BUFF(1))
      EQUIVALENCE (MFXF,COMM(19)),(ICPF,COMM(20))
      EQUIVALENCE(NPRNT,COMM(35)),(NAM1(1),NAM2(1))
      EQUIVALENCE(CHAR(1),COMM(126)),(NOFLD,COMM(21))
      DEFINE FILE 1(8160, 20,U,N1),2(300,12,U,N2),4(320,1,U,N4),
     &           5(1024,5,U,N5),6(42,15,U,N6),9(50,4,U,N9),
     +          7(40,60,U,N7),8(96,10,U,N8)
C...THIS IS A SPECIAL PROGRAM FOR PRINTING OUT RECORDS IN
C...CATEGORY GROUPINGS
C...STUDENT TRANSCRIPTS ARE GIVEN WITH AN EVALUATION OF ALL SCHOOL REQS.
C...SET UP GRADE SYMBOLS AND DEP. ABBRS.
      DO 4 I=1,32
    4 READ(9'I)DPNM(I,1),DPNM(I,2)
      DO 5 I 33,50
      II I-32
    5 READ(9'I)SG(II)
    6 CALL ERR(62)
      READ(6,908)IGO
  908 FORMAT(I1)
      GO TO (2,1,999),IGO
    1 IFRST = 1
      ILAST = COMM(26)
      GO TO 8
    2 CALL ERR(50)
      READ(6,910)IFRST
  910 FORMAT(I3)
      IF(IFRST-COMM(27))3,3,2
    3 ILAST = IFRST
    8 DO 100 I=IFRST,ILAST
      READ(2'I)IPNT,NUM,NAME
      IF(IPNT)100,100,9
    9 READ(2'IPNT)IPNT,MPT
      DO 90 JJ=1,11
      IF(MPT(JJ))90,90,40
   40 WRITE(NPRNT,900)NAME
  900 FORMAT('1ADVISOR',5X,10A2)
   10 CALL RMASR(MPT(JJ))
      CC= GFLD(22)/10.0
      GPA= GFLD(20)/1000.0
      KK=21
C...GVELF(N,KARY,K)
C...N IS THE SUBFIELD NO. OF THE VBL FIELD IN STURC
C...KARY IS ARRAY IN WHICH RETURN IS MADE
C...K IS DIMENSION OF KARY
C...ON RETURN K WILL BE LENGTH OF SUBFIELD OR ORIGINAL LENGTH OF
C...KARY, WHICHEVER IS SMALLER
      CALL GVELF(1,NAM1,KK)
      WRITE(NPRNT,901)NAM1,CC,GPA
  901 FORMAT(//,1X,21A1,5X,'CRS CRED=',F6.2,5X,'GPA=',F5.3//)
      IG=GFLD(25)
      CALL EXPAN(IG,RQ)
      IDEG= GFLD(8)
      WRITE(NPRNT,904)
  904 FORMAT(1X,'REQUIREMENTS REMAINING'/)
      ISH=20*(IDEG-1)
      NRQ=COMM(IDEG+30)
C...PRINT OUT REQUIREMENT DESCRIPTION IF NOT SATISFIED
      DO 70 L=1,NRQ
      IF(RQ(L))65,65,70
   65 IREC=ISH+L
      READ(6'IREC)NAM2
      WRITE(NPRNT,905)NAM2
  905 FORMAT(1X,15A2)
   70 CONTINUE
      WRITE(NPRNT,906)
```

```
906 FORMAT(//,1X,'COURSE',4X,'QTR/YR',2X,'C.C.',1X,'GD',2X,'GP'/)
    IFRST=NFXF+ICPF+2
    IGF=GFLD(4)
    IF(IGF)90,90,75
 75 LAST=IFRST+IGF*NOFLD
    DO 31 J=IFRST,LAST,NOFLD
    IDP= GFLD(J)
    ICS= GFLD(J+1)
    IDT= GFLD(J+5)
    IF(J-IFRST)23,22,23
 23 IF(IDT-KDT)21,25,21
 21 QAV=XGSUM/CCSUM
    WRITE(NPRNT,903)QAV
903 FORMAT('+',T35,'QTR.AVE. ',F5.3)
 22 KDT=IDT
    CCSUM=0.
    XGSUM=0.
 25 IF(IDT-20)24,26,26
 24 IQ=4
    IY=IDT+70
    GO TO 27
 26 IQ=IDT/100
    IY=IDT-IQ*100+50
    IQ=IQ+1
 27 IG= GFLD(J+4)
    CC= GFLD(J+3)/10.0
    CCSUM=CCSUM+CC
    XG=(IG-9)*CC
    IF(XG)29,30,30
 29 XG=0
 30 XGSUM=XGSUM+XG
 31 WRITE(NPRNT,902)DPNM(IDP,1),DPNM(IDP,2),ICS,IQ,IY,CC,SG(IG)  ,XG
902 FORMAT(1X,2A2,1X,I3,2X,I2,I3,3X,F3.1,2X,A2,2X,F3.1)
    QAV=XGSUM/CCSUM
    WRITE(NPRNT,903)QAV
 90 CONTINUE
    IF(IPNT)100,100,9
100 CONTINUE
    GO TO(999,6,999),IGO
999 CALL LINK(EXEC)
    END
```

SUBROUTINES USED IN STRIPE

** DRIVE

```
      SUBROUTINE DRIVE(IS,IW)
      INTEGER COMM(165),FLPTR(4),STORC(340)
      COMMON COMM,FLPTR,STORC,IERFL
      EQUIVALENCE(IF1,FLPTR(1)),(K1,FLPTR(2)),(IF2,FLPTR(3)),
     +           (K2,FLPTR(4))
C...FINE THE PHYSICAL FILE AND RECORD NUMBER CORRESPONDING TO THE O/GICAL
C...SECTOR AND WORD BLOCK POINTER.  COMM(9) THRU (13) SHOULD HAVE THE
C...CUMULATIVE TOTAL NO. OF SECTORS IN PHYSICAL FILES 1,11,21,31,41, RESP.
      IF(IS)999,999,5
    5 DO 100 I=9,13
      IF1=1+10*(I-9)
      K1=(IS-1)*16+IW+1
      IF(IS-COMM(I))10,11,100
   10 IF2=IF1
      K2=K1+16-IW
      GO TO 200
   11 IF2=IF1+10
      K2=1
      GO TO 200
  100 CONTINUE
C...MESSAGE IF SECTOR NUMBER IS TOO BIG
  999 CALL ERR(30)
      IERFL=2
  200 RETURN
```

** DRIVE

```
      SUBROUTINE DRIVE(IS,IW)
      INTEGER COMM(165),FLPTR(4),STORC(340)
      COMMON COMM,FLPTR,STORC,IERFL
      EQUIVALENCE(IF1,FLPTR(1)),(K1,FLPTR(2)),(IF2,FLPTR(3)),
     +           (K2,FLPTR(4))
C...FIND THE PHYSICAL FILE AND RECORD NUMBER CORRESPONDING TO THE D/GICAL
C...SECTOR AND WORD BLOCK POINTER.  COMM(9) THRU (13) SHOULD HAVE THE
C...CUMULATIVE TOTAL NO. OF SECTORS IN PHYSICAL FILES 1,11,21,31,41, RESP.
      IF(IS)999,999,5
    5 DO 100 I=9,13
      IF1=1+10*(I-9)
      K1=(IS-1)*16+IW+1
      IF(IS-COMM(I))10,11,100
   10 IF2=IF1
      K2=K1+16-IW
      GO TO 200
   11 IF2=IF1+10
      K2=1
      GO TO 200
  100 CONTINUE
C...MESSAGE IF SECTOR NUMBER IS TOO BIG
  999 CALL ERR(30)
      IERFL=2
  200 RETURN
      END
```

** ERR

```
      SUBROUTINE ERR(K)
      INTEGER MESS(10)
      READ(8'K)MESS
      WRITE(1,900)K,MESS
  900 FORMAT(I3,2X,10A2)
      RETURN
      END
```

** EXPAN

```
* CALL EXPAN(IW,IR)  PUTS THE BITS OF IW INTO
* THE 16 POSITION ARRAY IR (FORTRAN ORDER)
       ENT     EXPAN
EXPAN  DC      *-*
       LDX     2 16
       LDX     I1 EXPAN
       LD      I1 0
       SRT     16          PLACE IN EXTENSION
       LD      L1 1
       STO     L  1        STORE IT IN XR1
       SLA     16          ZERO ACCUMULATOR
SHIFT  SLT     1
       STO     L1 0
       SLA     16          ZERO ACCUMULATOR
       MDX     1 -1
       MDX     2 -1
       MDX     SHIFT
       MDM     EXPAN,+2
       BSC     I  EXPAN
       END
```

** FIELD

```
      SUBROUTINE FIELD(LINE,I,NF)
      INTEGER COMM(165),LINE(78)
      COMMON COMM
      EQUIVALENCE (COMM(141),IEFF)
C...RETURN -1 IF CHARACTER ISN'T F.  ELSE RETURN NUMBER
C...FOLLOWING F IF VALID
      IP=1
      NF=0
      K=I
      IF(LINE(I)-IEFF)10,20,10
   10 NF=-1
   15 RETURN
   20 K=K+1
C...CHECK NEXT CHAR.  IF NUMERIC BREAK OFF NUMERAL AND ACCUMULATE VAL.
   23 LK=LINE(K)
      IZ=IGVB(LK,0,3)
      IF(IZ-15)21,22,21
   21 GO TO(10,30),IP
   22 IZ=IGVB(LK,4,7)
      IP=2
      NF=NF*10+IZ
      GO TO 20
   30 I=K-1
      GO TO 15
      END
```

** GFLD

```
      FUNCTION GFLD(I)
      INTEGER COMM(165),FLPTR(4),STURC(340),M 2
      COMMON COMM,FLPTR,STURC,IERFL
      EQUIVALENCE (FLPTR(1),IFWD),(FLPTR(2),IFBT),(FLPTR(3),ILWD),
     +           (FLPTR(4),ILBT), M 2 ,X , M2,M 2  , M1,M 1
C...IERFL IS LEFT WITH VALUE 2 IF IT FAILS
      GFLD=0.0
C...GET WORD AND BIT POINTERS.  IFPTR PUTS THEM INTO FLPTR
      CALL IFPTR(I)
      GO TO(10,40),IERFL
   10 IF(IFWD-ILWD)15,30,30
   15 IF((ILWD-IFWD)*16+ILBT-IFBT-31)20,16,16
   16 I1 15-IFBT
      M2=IPVB(IGVB(STURC(IFWD),IFBT,15),IGVB(STURC(IFWD+1),0,IFBT-1),
     +  0,I1)
      M1=IPVB(IGVB(STURC(IFWD+1),IFBT,15),IGVB(STURC(ILWD),0,ILBT),0,I1)
      GFLD=X
      GO TO 40
   20 K1=14-ILBT
      GFLD=IPVB(IGVB(STURC(IFWD),IFBT,15),     0,0,K1) +
     +IGVB(STURC(ILWD),0,ILBT)
      RETURN
   30 GFLD=IGVB(STURC(IFWD),IFBT,ILBT)
   40 RETURN
      END
```

```
** GVBLF

      SUBROUTINE GVBLF(II,KARY,KK)
C...II TELLS WHICH SUBFIELD
C...KARY IS RETURN ARRAY
C...KK IS DIM. OF KARY.  IT RETURNS AS THE LENGTH OF SUBFIELD.
C...C...DONT CALL WITH KK AS A CONSTANT.  KARY IS BLANKED IF SUBFIELD
C...IS NOT PRESENT.
      INTEGER KARY(1),CHAR(40)
      INTEGER FLPTR(4)
      INTEGER COMM(165),STURC(340),BUFF(41)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (ICM14,COMM(14)),(ICM15,COMM(15)),(CHAR(1),COMM(126))
      EQUIVALENCE (L,KSTAT)
      DATA KBLNK/' '/
C...SEE IF VBL FIELD IS PRESENT
      KSTAT=STURC(1)
      IF(IGVB(KSTAT,1,1))10,10,20
   10 DO 15 I=1,KK
   15 KARY(I)=KBLNK
      KK=0
      RETURN
   20 KDISP=ICM14
C...SEE IF OPT. BLOCK IS PRESENT
      IF(IGVB(KSTAT,0,0))40,40,30
   30 KDISP=KDISP+ICM15
C...LENGTH OF VBL FIELD, BEGINNING, AND END
   40 L=GFLD(2)
      KEND=KDISP+L
      KDISP=KDISP+1
C...START EXAMINING SUB-FIELDS
   45 L=STURC(KDISP)
      NSUB=IGVB(L,0,7)
      LSUB=IGVB(L,8,15)
      IF(NSUB-II)50,60,50
   50 KDISP=KDISP+LSUB+1
      IF(KDISP-KEND)45,10,10
C...MAKE SURE KARY IS NOT OVERFLOWED
   60 L=LSUB*3
      IF(L-KK)70,70,65
   65 LSUB=KK/3
      GO TO 71
   70 KK=L
   71 CALL A3A1(STURC,KDISP+1,LSUB+KDISP,KARY,1,CHAR)
   75 RETURN
      END
```

** HASH1

```
      SUBROUTINE HASH1(KR,IRY,IR,IDIV,KEY)
      DIMENSION IRY(2)
C...THIS ACCESSES A CORE ARRAY WITH DESCRIPTOR INDEX IN IT
C...KEY DETERMINES WHETHER THIS IS A PUT, GET OR GET CONTINUED
      GO TO (1,2,12),KEY
    1 KSUB=0
      GO TO 3
    2 KSUB=KR
    3 K=0
      KRR=IABS(KR)
      CALL MOD(KRR,IQ,IR,IDIV)
      IF(IQ+1-IDIV)6,5,6
    5 IQ=0
    6 K=K+1
    7 IF(IRY(IR)-KSUB) 4,99, 4
    4 IF(KEY-1)10,8,10
    8 IF(IRY(IR)-KR)10,9,10
    9 IR=0
   99 RETURN
   10 IF(K-35)12,12,11
   11 IR=-1
      GO TO 99
   12 CALL MOD(IR+IQ,IP,IR,IDIV)
      GO TO 6
      END
```

** HSHF1

```
      SUBROUTINE HSHF1(KR,IR,IDIV,KEY,CSPTR)
      INTEGER CSPTR(4)
C...THIS ACCESSES THE DESCRIPTOR FILE ON DISK
C...KEY=1,2,3 FOR PUT, GET, OR GET CONTINUED
      GO TO (1,2,12),KEY
    1 KSUB=0
      GO TO 3
    2 KSUB=KR
    3 K=0
      KRR=IABS(KR)
      CALL MOD(KRR,IQ,IR,IDIV)
      IF(IQ+1-IDIV)6,5,6
    5 IQ=0
    6 K=K+1
    7 READ(3'IR)KID,CSPTR
      IF(KID-KSUB)10,99,10
   99 CSPTR(4)=IGVB(CSPTR(3),2,9)
      CSPTR(3)=IPVB(IGVB(CSPTR(2),9,15),0,7,13)+IGVB(CSPTR(3),0,1)
      CSPTR(2)=IGVB(CSPTR(2),3,8)
      RETURN
   10 IF(K-IDIV)12,12,11
   11 IR=-1
      GO TO 99
   12 CALL MOD(IR+IQ,IP,IR,IDIV)
      GO TO 6
      END
```

```
** HSHF2

      SUBROUTINE HSHF2(M,N,NP,IR,IDIV,KEY,IPTR)
C...THIS ACCESSES THE MASTER INDEX.  KEY=1,2,3 FOR PUT OR GET
      K=0
      X=M*1000.0+N
      CALL MODX(X,IC,IR,IDIV)
    7 GO TO(1,2),KEY
    1 XSUB=0
      GO TO 3
    2 XSUB=X
    3 IF(IC+1-IDIV)6,5,6
    5 IC=0
    6 READ(S'IR)MM,NN,NNN,IPTR
      Y=MM*1000.0+NN
      GO TO (18,17),KEY
   17 IF(MM)30,999,30
   18 IF(X-Y)25,29,25
   25 IF(MM)99,30,30
   29 CALL ERR(24)
      GO TO 999
   30 K=K+1
      IF(Y-XSUB)10,99,10
   99 RETURN
   10 IF(K-35)12,12,999
   12 CALL MOD(IR+IC,IP,IR,IDIV)
      GO TO 6
  999 IR=-1
      GO TO 99
      END
```

```
** HSHIX

      SUBROUTINE HSHIX(MINX,IDIV,KEY)
C... ACCESSES TEMPORARY FILE FOR MOVE INDEX IN GARBG
C...KEY=1 MEANS PUT ENTRY INTO INDEX.  KEY=2 MEANS FIND AN ENTRY
      INTEGER MINX(2),MV(2),IFLE(2,160),HI
      EQUIVALENCE (MV(1),M),(MV(2),N)
      DATA LO,HI/0,0/
C...SET POINTERS FOR IN CORE PART OF MOVE INDEX IF THIS IS FIRST CALL
      IF(LO)101,101,102
  101 LO=1
      HI=160
      READ(9'LO)IFLE
  102 IF(MINX(1))50,50,55
   50 MINX(2)=0
      GO TO 99
   55 K=0
      KX=MINX(1)
      CALL MOD(KX,IC,IR,IDIV)
    7 GO TO(1,2),KEY
    1 KSUB=0
      GO TO 3
    2 KSUB=KX
    3 IF(IC+1-IDIV)6,5,6
    5 IC=0
    6 IO=1
      GO TO 500
C...IF WE ARE TRYING TO  FIND AN ENTRY,I.E. KEY=2, AND WE RUN INTO
C...A ZERO THEN THE POINTER IS NOT IN THE INDEX.  THAT MEANS IT
C...IS FOR A RECORD THAT WAS NOT MOVED.  SET ITS NEW VALUE TO BE SAME
   17 IF(M)30,11,30
   18 IF(KX-M)30,29,30
   29 CALL ERR(24)
      GO TO 999
   30 K=K+1
      IF(M-KSUB)10,97,10
   97 GO TO(98,199),KEY
   98 IO=2
      GO TO 500
  199 MINX(2)=N
   99 RETURN
   10 IF(K-IDIV)12,12,11
C...IF POINTER IS NOT IN INDEX LEAVE IT UNCHANGED WHEN KEY =2
   11 GO TO (999,1100),KEY
 1100 MINX(2)=MINX(1)
      GO TO 99
   12 CALL MOD(IR+IC,IP,IR,IDIV)
      GO TO 6
  999 KEY=-1
      GO TO 99
  500 IF((LO-IR)*(IR-HI))210,200,200
  200 I=IR-LO+1
      GO TO(204,206),IO
  204 M=IFLE(1,I)
      N=IFLE(2,I)
      GO TO (18,17),KEY
  206 IFLE(1,I)=MINX(1)
      IFLE(2,I)=MINX(2)
      GO TO 99
  210 WRITE(9'LO)IFLE
      LO=(IR-1)/160*160+1
      HI=LO+159
      READ(9'LO)IFLE
      GO TO 500
      END
```

```
** IFPTR

      SUBROUTINE IFPTR(I)
      INTEGER COMM(165),FLPTR(4),STURC(340)
      COMMON COMM,FLPTR,STURC,IERFL
      EQUIVALENCE (STURC(1),IST),(STURC(2),IST2)
      EQUIVALENCE (FLPTR(1),IFWD),(FLPTR(2),IFBT),(MFIX,COMM(19)),
     +            (FLPTR(3),ILWD),(FLPTR(4),ILBT),(IOPT,COMM(20)),
     +            (MFXW,COMM(14)),(IOPW,COMM(15)),(NFVBL,COMM(21)),
     +            (NWVBL,COMM(16))
C...PRODUCE POINTER TO FIELD(I) OF MASTER RECORD
C...ROUTINE SHOULD RETURN FIRST WORD, FIRST BIT, LAST WORD, LAST BIT,
C...IN ARRAY FLPTR IN COMMON.  IERFL IS 2 IF IT FAILS.
      IP=IGVB(IST,0,0)
      MFIC=MFIX+ICPT
      IF(I-MFIX)100,100,11
   11 IF(I-MFIC)15,15,200
C...CHECK TO SEE IF CPT. BLOCK IS PRESENT
   15 IF(IP)201,201,100
  100 II=I+50
  101 IFRST=COMM(II)
      ILAST=COMM(II+1)-1
      IF(IFRST-ILAST)105,105,102
  102 IFBT=16
      RETURN
  105 IFWD=IFRST/16+1
      ILWD=ILAST/16+1
  110 IFBT=IFRST-(IFWD-1)*16
      ILBT=ILAST-(ILWD-1)*16
      RETURN
  200 MFIC1=MFIC+1
      IF(I-MFIC1)201,201,210
C...COPS. TRIED TO GET VBL FIELD
  201 IERFL=2
      RETURN
C...LOOKING AT FIELDS IN VBL BLOCK, FIRST COMP. START WORD OF BLOCK
  210 IVST=MFXW+ICPW*IP+IGVB(IST,8,14)
C...WHICH FIELD GROUP
      II=I-MFIC1
      III=II/NFVBL
      IIII=II-III*NFVBL
      IF(IIII)215,215,220
  215 IIII=NFVBL
C...NOW IVST POINTS TO BEG. OF GROUP OF FIELDS
C...IIII POINTS TO WHICH FIELD IN THE GROUP
  220 KCPT=MFIC1+IIII+50
      IVST=(IVST+III*NWVBL)*16
      IFRST=COMM(KCPT)+IVST
      ILAST=COMM(KCPT+1)-1+IVST
      GO TO 105
      END
```

** IPVB IGVB

```
       ENT     IGVB
       ENT     IPVB
*  CALL   K=IGVB(IWD,IF,IL)
*  RETURNS THE VALUE OF BITS IF THRU IL INCLUSIVE
IGVB   DC      *-*
       LDX  I1 IGVB
       LD   I1 1       - GET FIRST BIT POINTER
       A       SL
       STO     SLA     SET UP SHIFT LEFT
       LD      FIFTN   SET UP
       S    I1 2       FOR
       A    I1 1       SHIFT
       A       SR      TO THE
       STO     SRA     RIGHT
       LD   I1 0       LD WORD WITH DESIRED BITS
SLA    NOP
SRA    NOP
       MDX  L  IGVB,&3
       BSC  I  IGVB
*  CALL   K=IPVB(IVAL,IWD,IF,IL)
*  RETURNS THE VALUE OF IWD WITH BITS IF THRU IL
* REPLACED BY IVAL.  IWD IS UNCHANGED.
IPVB   DC      *-*
       LDX  I1 IPVB
       LD   I1 1       LOAD WORD TO BE FILLED
       STO     IWD
       LD   I1 2       LOAD FIRST BIT POINTER
       STO     IF
       LD   I1 3       LOAD LAST BIT POINTER
       STO     IL
       LD      FIFTN   SET UP
       S       IL      LENGTH OF
       STO     RT      RIGHT SHIFT.
       LD      IL      SET UP
       S       IF      SIZE
       A       ONE     OF
       STO     SIZE    BIT STRING.
       LDX   2 16      SET XR2 TO USE IN ERR CHECK.
       LD   I1 0       LOAD VALUE TO BE PUT IN.
       STO     IVAL
       SLCA  2         CHECK
       LD      SIZE    MAGNITUDE
       S    L  2       OF
       BNN     OK      IVAL.
       CALL    ERR     IF IVAL TOO BIG BRANCH
       DC      K36     TO ERR ROUTINE, THEN RETURN
       LD      IWD     ORIGINAL VALUE OF IWD.
       B       RET
*  IF ERROR CHECK IS NOT WANTED TAKE OUT FROM
*  LDX  2 16  TO HERE
*  IF ERR ROUTINE IS USED, THE ABOVE ASSUMES
*  ONE ARGUMENT.
OK     LD      IWD     LOAD THE WORD TO BE CHANGED
       LDX  I2 RT      XR2 USED FOR SHIFT COUNT
       SRT   2 0       ANY RT. HAND BITS TO BE
*                      KEPT, PUT IN EXT.
       LDX  I2 SIZE    XR2 USED FOR SHIFT TO ZERO
       SRA   2 0       OUT BITS TO BE CHANGED
       SLA   2 0
       OR      IVAL    INSERT NEW BITS
       LDX  I2 RT      XR2 USED AGAIN FOR SHIFT
       SLT   2 0       COUNT TO GET RT. HAND BITS BACK
RET    MDX  L  IPVB,4  SET UP RETURN ADDRESS
       BSC  I  IPVB
SR     SRA     0
SL     SLA     0
ONE    DC      1
FIFTN  DC      15
IF     DC      *-*
```

```
IL      DC      *-*
RT      DC      *-*
SIZE    DC      *-*
IWD     DC      *-*
IVAL    DC      *-*
K36     DC      36
        END
```

** INVRT

```
      SUBROUTINE INVRT(IFIL,IPT,ISZ,OLDPT,NEWPT,MPT)
      INTEGER CLDPT,MPT(1)
      INTEGER COMM(165),FLPTR(4),STURC(340),BUFF(41)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (COMM(30),ICM30),(COMM(37),ICM37)
C...IFIL IS THE FILE WHOSE INVERTED LIST IS TO BE CHANGED
C...IPT IS THE POINTER TO  THE INVERTED LIST FOUND IN CAT. OR DSC FILE
C...ISZ IS THE SIZE OF THE ARRAY MPT.  CORR. TO RECORD SIZE
C...OLDPT IS THE PTR VALUE TO BE CHANGED
C...NEWPT IS THE NEW PTR TO BE SUBSTITUTED FOR OLDPT.
IF OLDPT=0 WE ARE INSERTING A NEW PTR.
C...IF NEWPT=0 WE ARE DELETING AN OLD PTR.
   78 READ(IFIL'IPT)(MPT(I),I=1,ISZ)
      DO 80 I=2,ISZ
      IF(MPT(I)-OLDPT)80,85,80
   80 CONTINUE
      KPT=MPT(1)
      IF(KPT)82,82,79
   79 IPT=KPT
      GO TO 78
   82 IF(OLDPT)83,90,83
   83 CALL ERR(53)
      IERFL=2
   84 RETURN
C...INSERTING NEW ENTRY. NEED ANOTHER BLOCK OF SPACE
C...COMM(30) OR (37) POINTS AT THE NEXT AVAILABLE BLOCK.
   90 K=IFIL-1
      GO TO (91,92),K
   91 KVAIL=ICM30
      GO TO 95
   92 KVAIL=ICM37
   95 IF(KVAIL)83,83,100
  100 WRITE(IFIL'IPT)KVAIL
      IPT=KVAIL
      READ(IFIL'IPT)KVAIL
      GO TO(101,102),K
  101 ICM30=KVAIL
      GO TO 103
  102 ICM37=KVAIL
  103 DO 105 I=1,ISZ
  105 MPT(I)=0
      I=2
   85 MPT(I)=NEWPT
      WRITE(IFIL'IPT)(MPT(I),I=1,ISZ)
      GO TO 84
      END
```

```
** IPFLD

      SUBROUTINE IPFLD(K,X,I
      INTEGER COMM(165),FLPTR(4),STURC(340)
      INTEGER S1,M 2
      COMMCN CCMM,FLPTR,STURC,IERFL
      EQUIVALENCE (MFIX,COMM(19)),(IOPT,COMM(20)),(MFXW,COMM(14)),
     +            (IOPW,COMM(15)),(NFVBL,COMM(21)),(NWVBL,COMM(16)),
     +            (FLPTR(1),IFWD),(FLPTR(2),IFBT),(FLPTR(3),ILWD),
     +            (FLPTR(4),ILBT),(S1,STURC(1)), M 2 ,Z , M2,M 2  ,
     &             M1,M 1
C...PUTS THE VALUE K CR X INTO FIELD I DEPENDING ON WHETHER
C...FIELD I IS 16 BITS CR LESS OR IS 32 BITS.
C...IERFL IS 2 IF IT FAILS
C
C...GET WCRD AND BIT POINTERS
      CALL IFPTR(I)
      IF(IFBT-16)5,999,999
    5 GO TO(10, 99),IERFL
   10 IF(IFWD-ILWD)11,20,20
   11 IF((ILWD-IFWD)*16+ILBT-IFBT-31)30,12,35
   12 Z X
      IF(IFBT)14,14,15
   14 STURC(IFWD)=M2
      STURC(ILWD)=M1
      GO TO 25
   15 I1 15-IFBT
      STURC IFWD  IPVB IGVB M2,0,I1 ,STURC IFWD ,IFBT,15
      STURC IFWD&1  IPVB IGVB M2,I1&1,15 ,IGVB M1,0,I1 ,0,IFBT-1
      STURC ILWD  IPVB IGVB M1,I1&1,15 ,STURC ILWD ,0,ILBT
      GO TO 25
   20 IF(IFBT-16)21,999,999
   21 STURC(IFWD)=IPVB(K,STURC(IFWD),IFBT,ILBT)
   25 GO TO(999,99),IERFL
C...SET ERRCR FLAG IN RECORD
   99 S1=IPVB(1,S1,7,7)
  999 RETURN
   30 K1=ILBT - IFBT + 17
      IF(K1-16)32,40,40
   32 IF(K-2**K1)40,40,35
   35 CALL ERR(37)
      WRITE(1,900)K,I
  900 FORMAT(2I6)
      GO TO 99
   40 K2=15-ILBT
      STURC(ILWD)=IPVB(IGVB(K,K2,15),STURC(ILWD),0,ILBT)
      K1=16-K1
      K2=K2-1
      STURC(IFWD)=IPVB(IGVB(K,K1,K2),STURC(IFWD),IFBT,15)
      GO TO 25
      END
```

```
**IRLVL

      FUNCTION IRLVL M
      REAL VAL(25)
      INTEGER TCRIT
      INTEGER IVAL(50),CRIT(12),OP(4)
      INTEGER COMM 165 ,STORC 340 ,FLPTR 4 ,STOR1,KARY 20
      COMMON COMM,FLPTR,STORC,IERFL,OP,CRIT,IVAL
      EQUIVALENCE  COMM 21 ,ICM21 , COMM 20 ,ICM20 , COMM 19 ,ICM19 ,
     &            COMM 29 ,ICM29 , STORC 1 ,STOR1
C...RETURNS 1 OR 0 DEPENDING ON WHETHER THE CRITERION IS SATISFIED OR NO.
C...M POINTS TO CRITERION DESCRIPTION IN CRIT
C...VAL AND IVAL HOLD THE COMPARISON EXPRESSIONS
      EQUIVALENCE  VAL 1 ,IVAL 2
      IF(M-100)1,28,26
    1 TCRIT CRIT M
      KF IGVB TCRIT,0,5
      KR IGVB TCRIT,6,8
      KP IGVB TCRIT,11,15
      KT IGVB TCRIT,9,10 &1
C...FIRST GET VALUE OF FIELD. IF FIELD IS NON-EXISTENT, VALUE OF
C...FUNCTION IS 0.  IF A NUMERIC FIELD, FIRST FIND OUT
C...WHETHER FIELD IS IN MAND., OPT., VBL FIELD, OR VBL BLOCK.
      MOFL=ICM19+ICM20
      IF KF-ICM19 30,30,5
    5 ISF=KF-MOFL
      IF ISF 20,20,10
   10 KSF ISF-ICM29
      IF KSF 40,40,50
C...IS OPT BLOCK PRESENT
   20 IF IGVB STOR1,0,0  25,25,30
   25 IF KR-6 28,26,28
   26 IRLVL 1
   27 RETURN
   28 IRLVL 0
      GO TO 27
   30 IF KR-6 31,26,31
   31 X GFLD KF
      GO TO 100
C...ISF IS THE SUBFIELD IN THE VBL FIELD
C...IF VBL FIELD NOT PRESENT LENGTH WILL BE ZERO
C...LK RETURNS AS LENGTH OF SUBFIELD BUT NOT
C...GREATER THAN PRESET LENGTH OF KARY
   40 LK=20
      CALL GVBLF(ISF,KARY,LK)
      IF(LK)28,28,300
C...FIELD IS IN THE GROUPS IN THE VBL BLOCK. CALCULATE
C...REDUCED POINTER.  GET NO. OF GROUPS.
   50 KSF=KSF-KSF/ICM21*ICM21
      NGPS=GFLD(4)
      GO TO 400
C...NOW GET COMPARISON VALUE.  FIRST CHECK THAT TYPE
C...IS RIGHT.  KT SHOULD BE 1,2,OR 3 FOR NUMERIC.
  100 GO TO(115,115,120,105),KT
  105 CALL ERR(55)
      GO TO 28
C...INTEGER VALUE
C...REAL MODE VALUE
  115 KP=(KP+2)/2
      XX=VAL(KP)
      GO TO 200
C...FIELD EXPRESSION. POINTER INDICATES BEGINNING OF EXPRESSION
C...IN IVAL.  EXPRESSION FORM IS AS FOLLOWS--AN OPERATION IS GIVEN
C...FOLLOWED BY EITHER A FIELD OR A NUMERIC VALUE.  OPERATIONS ARE
C...+,-,*,/ CODED AS 1,2,3,OR 4, RESP.  IF THE OP. IS FOLLOWED BY A
C...FIELD, THE OP CODE IS POSITIVE.  IF A NUMERIC FOLLOWS, THE OP IS
C...NEGATIVE.  AN OP OF ZERO ENDS THE ESPRESSION.
C...EVALUATION IS STRICTLY LEFT TO RIGHT.
  120 XX=0.0
  125 IOP=IVAL(KP)
      IF(ICP)130,200,140
```

```
C...NUMERIC VALUE
  130 IOP=-ICP
      KP=KP+4
      K=KP/2
      XK=VAL(K)
      GO TO 150
C...FIELD VALUE
  140 XK=GFLD(IVAL(KP+1))
      KP=KP+2
  150 GO TO(155,160,165,170),IOP
  155 XX=XX+XK
      GO TO 125
  160 XX=XX-XK
      GO TO 125
  165 XX=XX*XK
      GO TO 125
  170 XX=XX/XK
      GO TO 125
C...COMPARE VALUES, NUMERIC
  200 IF(X-XX)330,325,340
C...COMPARE STRINGS.  LK IS LENGTH FIELD STRING.
C...LENGTH OF TEST STRING IS IN IVAL(KP)
  300 LT=IVAL(KP)
      IF(LK-LT)305,310,310
  305 LT=LK
  310 DO 320 I=1,LT
      II=KP+I
      IF(KARY(I)-IVAL(II))330,320,340
  320 CONTINUE
  325 GO TO(28,26,26,26,28,26),KR
  330 GO TO(26,26,28,28,28,26),KR
  340 GO TO(28,28,28,26,26,26),KR
C...CHECK FOR FIELD IN EACH GROUP IN VBL BLOCK
C...KSF SHOULD BE FROM 1 TO ICM21.  ONLY CHECK EQUAL
  400 KSF=KSF+1+MOFL
      DO 500 I=1,NGPS
      IF(X-GFLD(KSF))500,26,500
  500 KSF=KSF+ICM21
      GO TO 28
      END
```

```
** IRTRV

      SUBROUTINE IRTRV(ISW,I,KEY)
      INTEGER HL,HH,HBUF(200),LBUF(200)
      DATA LL,LH,HL,HH/32000,32000,0,0/,IN/1/
C...THIS IS A BUFFER ROUTINE TO ACCESS THE SET OF POINTERS PUT ON FILE
C...BY SLECT AND USED BY LISTM, ARRNG, STATS.  KEY=1,2, OR 3 FOR
C...GET, PUT OR RETURN BUFFER TO FILE.  BUFFER IS IN
C...TWO PARTS FOR MORE EFFICIENT USE IN ARRNG.
      GO TO(10,10,31),KEY
   10 IF(LL-I)12,15,30
   12 IF(LH-I)35,15,15
   15 J=I-LL+1
      GO TO(20,25),KEY
   20 LBUF(J)=ISW
      GO TO 99
   25 ISW=LBUF(J)
      GO TO 99
C...NEED NEW LOW BUFFER.  PUT PRESENT ONE BACK FIRST.
   30 GO TO(32,31),IN
   31 WRITE(9'LL)LBUF
      GO TO(32,32,60),KEY
   32 LL=(I-1)/200*200+1
      LH=LL+199
      GO TO(34,33),IN
   34 HL=LL+200
      HH=LH+200
   33 READ(9'LL)LBUF
      GO TO(62,10),IN
C...NEED NEW HIGH BUFFER.  PUT PRESENT ONE BACK FIRST
   60 WRITE(9'HL)HBUF
      GO TO(61,61,99),KEY
   61 HL=(I-1)/200*200+1
      IN=2
      HH=HL+199
   62 READ(9'HL)HBUF
      GO TO 10
   35 IF(HL-I)40,45,30
   40 IF(HH-I)60,45,45
   45 J=I-HL+1
      GO TO(50,55),KEY
   50 HBUF(J)=ISW
      GO TO 99
   55 ISW=HBUF(J)
   99 RETURN
      END
*ONE WORD INTEGERS
```

** LADCH

```
      SUBROUTINE LADCH
      INTEGER ADVNM(10),CHAR(40)
      INTEGER COMM(165),STURC(340),BUFF(41),FLPTR(4)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE(COMM(27),ICM27)
      EQUIVALENCE (NPRNT,COMM(35))
      EQUIVALENCE (CHAR(1),COMM(126))
C...PRODUCE A LIST OF PRIME KEYS OF RECORDS IN CATEGORIES
    1 CALL ERR(62)
      READ(6,901)IAN
  901 FORMAT(I1)
      IF(IAN-3)5,5,1
    5 GO TO (10,50,99),IAN
   10 CALL ERR(60)
      READ(6,903)NUM
  903 FORMAT(I3)
      NUM1=NUM
      NUM2=NUM
      GO TO 60
   50 NUM1=1
      NUM2=ICM27
   60 DO 100 J=NUM1,NUM2
      READ 2 J IPNT,NMBR,ADVNM
      WRITE NPRNT,904 IPNT,NMBR,ADVNM
  904 FORMAT 1X,2I4,1X,10A2/
   64 IF IPNT 100,100,65
   65 READ 2 IPNT IPNT,ADVNM
      DO 90 I 1,11
      IF ADVNM I  90,90,70
   70 CALL RMASR(ADVNM(I))
      M=GFLD(5)
      N=GFLD(6)
      NN=GFLD(7)
      WRITE(5,905)M,N,NN
  905 FORMAT(1X,3I3)
   90 CONTINUE
      IF IPNT 100,100,65
  100 CONTINUE
      GO TO 1
   99 RETURN
      END
```

```
** LEARF

      SUBRCUTINE LEARF
      INTEGER COMM(165),STURC(340),BUFF(60),FLPTR(4)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (NPRNT,COMM(35))
C...LIST FILES USED FOR AUXILIARY PURPOSES
    1 CALL ERR(58)
      CALL ERR(59)
      READ 6,903 IFL
  903 FORMAT I1
      IFL IFL-5
      IF IFL 9,9,5
    9 RETURN
    5 IF IFL-4 6,6,1
    6 GO TO 600,700,800,9000 ,IFL
  600 DO 42 I=1,42
      READ(6'I)(BUFF(J),J=1,15)
      WRITE(NPRNT,910)(BUFF(J),J=1,15)
  910 FORMAT 1X,15A2
   42 CONTINUE
      GO TO 1
  700 DO 70 I 1,40
      READ(7'I)BUFF
   70 WRITE NPRNT,911 BUFF
  911 FORMAT(1X,4(1518,/))
      GO TO 1
  800 DO 80 I 1,64
      READ(8'I)(BUFF(J),J=1,10)
   80 WRITE(NPRNT,912)(BUFF(J),J=1,10)
  912 FORMAT 1X,10A2
      GO TO 1
 9000 DO 20 I 1,50
      READ(9'I)KA,KB,KC,KD
   20 WRITE 5,900 KA,KB,KC,KD
  900 FORMAT 1X,4A2
      GO TO 1
      END
```

```
**LISTM

      SUBROUTINE LISTM
      INTEGER ST1,DCLSL
      INTEGER COMM(165),FLPTR(4),STURC(340),OP(4),CRIT(12),IVAL(50),SPTR
      COMMON COMM,FLPTR,STURC,IERFL,OP,CRIT,IVAL,SPTR
      EQUIVALENCE (STURC(1),ST1),(COMM(125),DCLSL)
C...LIST RECORDS WHOSE POINTERS ARE IN WORKING SET
C...NEED TO ADD FACILITY TO LIST SPECIFIC FIELDS.  USE CRIT AND IVAL
      IF(SPTR)4,4,5
    4 CALL ERR(57)
      GO TO 99
    5 DO 100 I=1,SPTR
      CALL IRTRV(ISCWD,I,2)
      IF(ISCWD)10,100,10
   10 CALL RMASR(ISCWD)
      IF(ST1-DCLSL)20,15,20
   15 CALL ERR(6)
      GO TO 100
   20 CALL LSTMR
  100 CONTINUE
   99 RETURN
      END
```

** LCCGP

```
      FUNCTION LCCGP(I1,I2,I3)
      INTEGER COMM(165),FLPTR(4),STORC(340)
      COMMON COMM,FLPTR,STORC,IERFL
      EQUIVALENCE (COMM(20),ICM20),(COMM(19),ICM19),(COMM(21),ICM21)
      LCCGP=0
      IFFGP=ICM19+ICM20+2
      IG=GFLD(4)
      IFLGP=IFFGP+(IG-1)*ICM21
    1 IF(IFLGP-IFFGP)5,10,10
    5 RETURN
   10 IF(I1-GFLD(IFLGP))30,15,30
   15 IF(I2-GFLD(IFLGP+1))30,20,30
   20 IF(I3-GFLD(IFLGP+2))30,25,30
   25 LCCGP=IFLGP
      RETURN
   30 IFLGP=IFLGP-ICM21
      GO TO 1
      END
```

```
** LPADV

      SUBROUTINE LPADV
      INTEGER ADVSR(12)
      INTEGER COMM(165),STORC(340),BUFF(41),FLPTR(4)
      COMMON COMM,FLPTR,STORC,IERFL,BUFF
      EQUIVALENCE (COMM(27),ICM27)
      EQUIVALENCE(NPRNT,COMM(35))
      EQUIVALENCE (IPNT,ADVSR(1))
C...LIST OR PATCH CATEGORY FILE
    1 CALL ERR(56)
      READ(6,91)I
   91 FORMAT(I1)
      GO TO (10,100,99),I
   10 CALL ERR(54)
      READ(6,91)I
      GO TO(11,12),I
   11 CALL ERR(52)
      READ(6,94)N1
      N2=N1
      GO TO 15
   12 N1=1
      N2=ICM27
   15 DO 50 I=N1,N2
      READ(2'I)ADVSR
      IF(IPNT)50,50,30
   30 WRITE(NPRNT,90)ADVSR
   90 FORMAT(1X,2I4,1X,10A2)
   35 READ(2'IPNT)ADVSR
      WRITE(NPRNT,96)ADVSR
   96 FORMAT(1X,12I7)
      IF(IPNT)50,50,35
   50 WRITE(NPRNT,97)
   97 FORMAT(/)
      GO TO 1
   99 RETURN
  100 CALL ERR(51)
      READ(6,91)KK
      CALL ERR(50)
      READ(6,94)K
   94 FORMAT(I3)
      READ(2'K)ADVSR
      GO TO(101,201),KK
  101 WRITE(1,95)ADVSR
   95 FORMAT(2I4,1X,10A2)
      READ(6,95)ADVSR
  202 WRITE(2'K)ADVSR
      GO TO 1
  201 WRITE(1,96)ADVSR
      CALL ERR(49)
      READ(6,94)IF,IVAL
      ADVSR(IF)=IVAL
      GO TO 202
      END
```

** LPCOM

```
      SUBROUTINE LPCOM
      INTEGER COMM(165),STURC(340),BUFF(41),FLPTR(4)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE  NPRNT,COMM 35
C...LIST OR PATCH PARAMETER FILE
      READ(4'1)COMM
    1 CALL ERR(56)
      READ(6,909)IGO
  909 FORMAT(I1)
      IF(IGO)1,1,2
    2 IF(IGO-3)3,3,1
    3 CONTINUE
      GO TO(10,100,999),IGO
   10 WRITE(NPRNT,910)COMM
  910 FORMAT(1X,10I10)
      GO TO 1
  100 CONTINUE
      CALL ERR(47)
      CALL ERR(48)
      READ(6,91)K,IV
   91 FORMAT(I4)
      IF(K)5,999,5
    5 COMM(K)=IV
      GO TO 1
  999 WRITE(4'1)COMM
      RETURN
      END
```

```
** LPCRS

      SUBROUTINE LPCRS
      INTEGER CB(30)
      INTEGER COMM(165),STURC(340),BUFF(41),FLPTR(4)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE(CB(1),BUFF(1)),(KID,BUFF(1)),(KCH,BUFF(2))
      EQUIVALENCE (COMM(24),IDIV),(IAN,BUFF(31)),(KSTAT,BUFF(32)),
     +            (KD,BUFF(33)),(KN,BUFF(34)),(KS,BUFF(35))
      EQUIVALENCE(BUFF(3),IBF3),(BUFF(4),IBF4),(BUFF(5),IBF5),
     +           (BUFF(6),IBF6),(BUFF(7),IBF7),(BUFF(8),IBF8),
     +           (BUFF(9),IBF9)
C...LIST CR PATCH DESCRIPTORS.  NOT GENERALIZED YET
    1 CALL ERR(56)
      READ(6,901)IAN
  901 FORMAT(I1)
      IF(IAN)1,1,2
    2 IF(IAN-3)5,5,1
    5 GO TO (10,100,999),IAN
   10 CONTINUE
      CALL ERR(46)
      READ(6,901) IAN
      IF(IAN-2)6,8,8
    6 WRITE(1,906)
  906 FORMAT('TYPE INCLUSIVE RECORD NOS. IN 2I3')
      READ(6,908)I1,I2
  908 FORMAT(2I3)
      GO TO 11
    8 I1=1
      I2=IDIV
   11 DO 20 I=I1,I2
      READ(3'I)CB
      IF(KID)15,20,15
   15 KSTAT=IGVB(IBF3,0,2)
      KD=IGVB(IBF3    ,3,8)
      KN=IPVB(IGVB(IBF3    ,9,15),IGVB(IBF4    ,0,1),7,13)
      KS=IGVB(IBF4    ,2,9)
      KCC=IGVB(IBF4    ,10,15)
      KDT=IGVB(IBF5    ,0,7)
      KNUM=IGVB(IBF5    ,8,15)
      KMX=IGVB(IBF6    ,0,7)
      KH=IGVB(IBF6    ,8,11)
      KINST=IGVB(IBF7    ,0,2)
      IAN=IGVB(IBF6    ,12,15)
      KINST=IPVB(IAN,KINST,9,12)
      KBLDG=IPVB(IGVB(IBF7    ,3,15),IGVB(IBF8    ,0,2),0,12)
      KROOM=IPVB(IGVB(IBF8    ,3,15),IGVB(IBF9    ,0,2),0,12)
      KEX=IGVB(IBF9,3,15)
      WRITE(5,902)I,KID,KCH,KSTAT,KD,KN,KS,KCC,KDT,KNUM,KMX,KH,KINST,
     + KBLDG,KROOM,KEX,(BUFF(J),J=9,29)
  902 FORMAT(/1X,13I6,2A2,I6/,1X,8A2,2X,8A2,2X,5A2)
   16 READ(3'KCH)CB
      WRITE(5,905)CB
  905 FORMAT(1X,15I6)
      IF(KID)20,20,17
   17 KCH=KID
      GO TO 16
   20 CONTINUE
      GO TO 1
  100 CALL ERR(44)
      READ(6,904)IR,IW,IV
  904 FORMAT(3I6)
      READ(3'IR)CB
      CB(IW)=IV
      WRITE(3'IR)CB
      GO TO 1
  999 RETURN
      END
```

```
** LPINX

      SUBROUTINE LPINX
      INTEGER COMM(165),STURC(340),BUFF(41),FLPTR(4)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (COMM(7),ICM7)
      EQUIVALENCE (NPRNT,COMM(35))
C...LIST OR PATCH MASTER INDEX
    1 CALL ERR(56)
      READ(6,930)IAN
  930 FORMAT(I1)
      GO TO(10,100,999),IAN
   10 DO 50 I=1,ICM7
      READ(5'I)MM,NN,NNN,ISW,NKEY
      IF(MM)727,50,727
  727 WRITE(NPRNT,900)I,MM,NN,NNN,ISW,NKEY
  900 FORMAT(1X14,1X, 3I3,2X,I6, I7
   50 CONTINUE
      GO TO 1
  100 CALL ERR(43)
      READ(6,905)M,N
  905 FORMAT(2I3)
      IF(M)101,999,101
  101 DO 150 I=1,1021
      READ(5'I)MM,NN,NNN,ISCWD,NKEY
      IF(M-MM)150,110,150
  110 IF(N-NN)150,160,150
  150 CONTINUE
      WRITE(1,906)
  906 FORMAT('NOT FOUND')
      GO TO 100
  160 WRITE(1,907)MM,NN,NNN,ISCWD,NKEY
  907 FORMAT('RCRD CURRENTLY'/3I3,2X, I6,I7,3X,'TYPE NEW RECORD DIRECTLY
     + UNDERNEATH'/)
      READ(6,908)MM,NN,NNN,ISCWD,NKEY
  908 FORMAT(3I3,2X, I6,I7,)
      WRITE(5'I)MM,NN,NNN,ISCWD,NKEY
      GO TO 1
  999 RETURN
      END
```

```
**LPMR

      SUBROUTINE LPMR
      INTEGER FLPTR(4)
      INTEGER STURC(340),DOLSL,         COMM(165),CHAR(40),BUFF(100)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      DATA DOLSL/'$'/
      EQUIVALENCE (IDIV,COMM(7)),(CHAR(1),COMM(126)),(IFRS,STURC(1)),
     +            (ICM19,COMM(19)),(ICM20,COMM(20)),(BUFF(1),IFLTR),
     +  "       (ICM29,COMM(29)),(ICM21,COMM(21)),(COMM(16),ICM16)
      EQUIVALENCE (NPRNT,COMM(35))
C...LIST OR PATCH MASTER RECORD
   10 IERFL=1
      CALL ERR(56)
      READ(6,802)ILP
      GO TO (7,7,99),ILP
    7 CALL ERR(42)
      READ(6,802)IGC
  802 FORMAT(I1)
      IF(IGC-2)1,600,99
  600 READ(6,803)ISC,ISW
  803 FORMAT(2I3)
      IPTR=IPVB(ISC,ISW,0,11)
      IF(ISC)10,10,4
    1 READ(6,800)M,N,NN
  800 FORMAT(3I3)
      IF(M)5,10,5
    5 CALL HSHF2 M,N,NN,K,IDIV,2,IPTR
      ISC=IGVB(IPTR,0,11)
      ISW=IGVB(IPTR,12,15)
      IF(K)6,6,4
    6 CALL ERR(7)
      GO TO 10
    4 CALL RMASR(IPTR,3)
      GO TO(200,10),IERFL
  200 IF(IFRS-DOLSL)3,2,3
    2 N=STURC(8)
      GO TO 55
C...FIRST PRINT OUT SECTOR, WORD, AND VBL FIELDS
    3 WRITE(NPRNT,901)ISC,ISW
  901 FORMAT(1X,2I4)
      CALL LSTMR
      GO TO 1000
   55 WRITE(1,903)N,STURC(9),STURC(10)
  903 FORMAT('FREE AREA ',3I8)
 1000 GO TO(10,1200),ILP
 1200 CALL ERR(41)
      READ(6,802)ILP
      CALL ERR(40)
      READ(6,807) IFW,IVAL
  807 FORMAT(I3,I6)
      GO TO(210,220),ILP
  210 CALL IPFLD(IVAL,X,IFW)
      GO TO 230
  220 STURC(IFW)=IVAL
  230 CALL WMASR(IPTR,0)
      ILP=1
      GO TO 200
   99 RETURN
      END
```

```
**LSTMR
      SUBROUTINE LSTMR
      INTEGER COMM(165),FLPTR(4),STURC(340),BUFF( 67),CHAR(40)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (CHAR(1),COMM(126))
      EQUIVALENCE (IDIV,COMM(7)),(CHAR(1),COMM(126)),(IFRS,STURC(1)),
     +            (ICM19,COMM(19)),(ICM20,COMM(20)),(BUFF(1),IFLTR),
     +          (ICM29,COMM(29)),(ICM21,COMM(21)),(COMM(35),NPRNT)
C...LIST THE MASTER RECORD CURRENTLY IN STURC
      N=GFLD(3)
      KL=67
      J=1
   76 CALL GVBLF(J,BUFF,KL)
      IF(IFLTR-16448)78,77,78
   78 WRITE(NPRNT,905)(BUFF(I),I=1,KL)
  905 FORMAT(1X,80A1)
   77 J=J+1
      IF(J-ICM29)76,76,300
C...NOW PRINT MAND. AND OPT. BLOCKS
  300 J=1
      IC=ICM19
      K=1
      KK=10
   12 IF(KK-IC)15,15,11
   11 KK=IC
      J=J+1
   15 II=0
      DO 20 I=K,KK
      II=II+1
   20 BUFF(II)=GFLD(I)
      WRITE(NPRNT,900)(BUFF(I),I=1,II)
  900 FORMAT(1X,10I8)
      KK=KK+10
      K=K+10
      GO TO(12,25,12,35),J
C...SEE IF OPT. BLOCK IS PRESENT
   25 IG=GFLD(1)
      IC=ICM19+ICM20+1
      IF(IGVB(IG,0,0))35,35,30
   30 J=3
      K=ICM19+1
      KK=K+9
      GO TO 12
   35 CONTINUE
C...PRINT OUT EXPERIMENTAL REAL FIELD
      Z=GFLD(27)
      WRITE NPRNT,906 Z
  906 FORMAT 1X,F10.5
```

```
**LSTMR

      SUBROUTINE LSTMR
      INTEGER COMM(165),FLPTR(4),STURC(340),BUFF( 67),CHAR(40)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (CHAR(1),COMM(126))
      EQUIVALENCE (IDIV,COMM(7)),(CHAR(1),COMM(126)),(IFRS,STURC(1)),
     +            (ICM19,COMM(19)),(ICM20,COMM(20)),(BUFF(1),IFLTR),
     +           (ICM29,COMM(29)),(ICM21,COMM(21)),(COMM(35),NPRNT)
C...LIST THE MASTER RECORD CURRENTLY IN STURC
      N=GFLD(3)
      KL=67
      J=1
   76 CALL GVBLF(J,BUFF,KL)
      IF(IFLTR-16448)78,77,78
   78 WRITE(NPRNT,905)(BUFF(I),I=1,KL)
  905 FORMAT(1X,80A1)
   77 J=J+1
      IF(J-ICM29)76,76,300
C...NOW PRINT MAND. AND OPT. BLOCKS
  300 J=1
      IC=ICM19
      K=1
      KK=10
   12 IF(KK-IC)15,15,11
   11 KK=IC
      J=J+1
   15 II=0
      DO 20 I=K,KK
      II=II+1
   20 BUFF(II)=GFLD(I)
      WRITE(NPRNT,900)(BUFF(I),I=1,II)
  900 FORMAT(1X,10I8)
      KK=KK+10
      K=K+10
      GO TO(12,25,12,35),J
C...SEE IF OPT. BLOCK IS PRESENT
   25 IG=GFLD(1)
      IC=ICM19+ICM20+I
      IF(IGVB(IG,0,0))35,35,30
   30 J=3
      K=ICM19+1
      KK=K+9
      GO TO 12
   35 CONTINUE
C...PRINT OUT EXPERIMENTAL REAL FIELD
      Z=GFLD(27)
      WRITE NPRNT,906 Z
  906 FORMAT 1X,F10.5
C...PRINT OUT VBL GROUPS
C...FORMAT USED HERE IS LOCAL
C...GET NUMBER OF GROUPS IN VBL BLOCK
      NGPS= GFLD(4)
      IF(NGPS)1000,1000,50
C...ICM21 IS NO. OF FIELDS PER GROUP
C...J IS FIELD NUMBER POINTER
   50 J=IC
      ICM=ICM21-1
      IC3=ICM*3
      DO 100 I=1,NGPS,3
      KK=1
      DO 80 L=1,3
      DO 70 K=1,ICM
      BUFF(KK)=GFLD(J+KK)
   70 KK=KK+1
   80 J=J+1
      WRITE(NPRNT,902)(BUFF(KK),KK=1,IC3)
  902 FORMAT(1X,3(2I4,A1,3I6,5X))
      J=J+IC3
  100 CONTINUE
 1000 WRITE(NPRNT,910)
```

```
910 FORMAT(///)
    RETURN
    END
```

```
** NUMBR

      SUBROUTINE NUMBR(LINE,I,X,ITYP)
      INTEGER LINE(78),COMM(165),FLPTR(4),STORC(340),OP(4),PLUS,
     +PER
      COMMON COMM,FLPTR,STORC,IERFL,OP
      EQUIVALENCE(PLUS,OP(1)),(MINUS,OP(2)),(COMM(164),PER)
      EQUIVALENCE (COMM(132),KBLNK)
C...CONVERT A STRING OF CHARACTERS TO NUMERIC VALUE. IGNORE LEADING BLANKS
C...I  IS COLUMN OF LINE TO START EXAMINING.  ON RETURN I IS COLUMN
C...OF LAST CHAR. OF NUMBER.  VALUE IS RETURNED IN X.
      L=-1
      K=I
      IP=1
      SIGN=1.0
      SUM=0.0
      PSUM=0.0
      ITYP =0
    2 IF(LINE(K)-KBLNK)3,8,3
    8 K=K+1
      GO TO 2
    3 IF(LINE(K)-MINUS)4,5,4
    4 IF(LINE(K)-PLUS)6,7,6
    5 SIGN=-1.0
    7 K=K+1
C...CHECK FOR POINT
    6 LI=LINE(K)
      IF(LI-PER)15,50,15
C...EXTRACT DIGIT
   15 IZ=IGVB(LI,0,3)
      IF(IZ-15)25,20,25
   20 IZ=IGVB(LI,4,7)
      IF(IZ-9)30,30,25
   25 GO TO(26,70),IP
   26 ITYP=2
      I=K
      RETURN
   30 SUM=SUM*10.0+IZ
      IP=2
      GO TO 7
   50 K=K+1
      LI=LINE(K)
      IP=2
      IZ=IGVB(LI,0,3)
      IF(IZ-15)25,55,25
   55 IZ=IGVB(LI,4,7)
      IF(IZ-9)60,60,25
   60 Z=IZ
      PSUM=PSUM+Z*10.0**L
      L=L-1
      ITYP=1
      GO TO 50
   70 X=SUM+PSUM
      X=X*SIGN
      I=K-1
      RETURN
      END
```

** MOD

```
      SUBROUTINE MOD(K,IQ,IR,IDIV)
C...MODULUS FUNCTION FOR HASHING.  IQ IS QUOTIENT OF K/IDIV. IR IS REM.
      IQ=K/IDIV
      IR=K-IQ*IDIV+1
      RETURN
      END
```

** MODX

```
      SUBROUTINE MODX(X,IQ,IR,IDIV)
C...REAL MODE FORM OF MOD
      IQ=X/IDIV
      XQ=IQ
      IR=X-XQ*IDIV+1.0
      RETURN
      END
```

```
** PCLST

      SUBROUTINE PCLST(XP,I,J,TXP)
      INTEGER LP1,RP1
      INTEGER XP(80),RP,PCNT,TXP(80)
      INTEGER COMM(165),FLPTR(4),STURC(340),BUFF(41)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (COMM(34),KARD),(NPRNT,COMM(35))
C...THIS ROUTINE SORTS A STRING REPRESENTING A BOOLEAN EXPRESSION
C...INTO ORDER SUCH THAT THE ATOMS AND PARENTHESIZED GROUPS
C...COME FIRST IN THE SAME RELATIVE ORDER FOLLOWED BY THE
C...OPERATION CODES IN REVERSE ORDER.  ( IS CODED AS 0.
C...) IS CODED AS -1.  & IS CODED AS -2.     AS -3.
C...THE ATOMS ARE POSITIVE NUMBERS REPRESENTING CRITERIA DESCRIBED
C...IN CRIT.
      NGM=I
    5 NGMIN=J
      IPREV=1
      NSORT=1
      II=NGM
    8 IF(XP(II))10,20,10
   10 IF(XP(II))71,15,15
   15 RP=II
      GO TO 50
C...FIND BALANCING RT. PARENTHESIS
   20 III=II+1
      PCNT=0
   21 IF(XP(III)+1)24,22,24
   22 IF(PCNT)26,23,28
   23 RP=III
      GO TO 50
   24 IF(XP(III))27,25,27
   25 PCNT=PCNT+1
   27 III=III+1
      IF(III-J)21,21,26
   26 CONTINUE
      CALL ERR(39)
      RETURN
   28 PCNT=PCNT-1
      GO TO 27
   50 IF(IPREV)55,55,70
   55 LP=II
      DO 500 LL=LP1,RP1
  500 TXP(LL)=XP(LL)
      ID=RP-LP
      IDJ=LP1+ID
      KK=LP
      DO 400 LL=LP1,IDJ
      XP(LL)=XP(KK)
  400 KK=KK+1
      ID=RP1-LP1
      IDJ=RP-ID
      KK=LP1
      DO 300 LL=IDJ,RP
      XP(LL)=TXP(KK)
  300 KK=KK+1
      KK=LP1+RP-LP+1
      IF(NGMIN-KK)65,65,60
   60 NGMIN=KK
   65 NSORT=2
      LP1=RP
      RP1=RP
   70 II=RP+1
      GO TO 74
   71 LP1=II
      RP1=II
      IPREV=-1
      II=II+1
   74 IF(II-J)8,8,75
   75 GO TO (85,80),NSORT
   80 NGM=NGMIN
```

```
** PVELF

      SUBROUTINE PVELF(ISFLD,KARY,N)
      INTEGER KARY(1)
      INTEGER CCMM(165),FLPTR(4),STORC(340)
      COMMON CCMM,FLPTR,STORC,IERFL
      EQUIVALENCE (STORC(1),IST)
      EQUIVALENCE (CCMM(15),ICM15),(CCMM(14),ICM14)
C...ISFLD IS THE NO. OF SUBFIELD TO PUT IN. KARY IS ARRAY HOLDING
C...IT.  N IS NO. OF WORDS IN SUBFIELD NOT COUNTING HEADER.
C...SEE IF VBL FIELD IS PRESENT
      IV=IGVB(IST,1,1)+1
C...GET WORD POINTER TO VBL FIELD POSITION
      ID=ICM14+IGVB(IST,0,0)*ICM15+1
      LVF=GFLD(2)
      GO TO(50,10),IV
C...IS THERE ALREADY SUBFIELD ISFLD IN VBL FIELD
   10 LVBL=ID+LVF
   12 IHD=STORC(ID)
      IS=IGVB(IHD,0,7)
      IL=IGVB(IHD,8,15)
      IF(IS-ISFLD)15,25,15
   15 ID=ID+IL
      IF(KTS-LVBL)12,20,20
   20 IDIF=N
      GO TO 30
C...FOUND SUBFIELD
   25 IDIF=N-IL
      IF(IDIF)30,35,30
   30 CALL SHOVE(ID,IDIF)
      GO TO(31,100),IERFL
C...CHANGE LENGTH PARAMETER FOR VBL FIELD
   31 CALL IPFLD(LVF+IDIF,X,2)
C...PUT IN SUBFIELD
      STORC(ID)=IPVE(N+1,IHD,8,15)
   35 IS=ID+1
      DO 40 I=1,N
      STORC(IS)=KARY(I)
   40 IS=IS+1
  100 RETURN
      END
```

```
      GO TO 5
C...NOW INVERT ORDER FROM NGM TO J POSITION
   85 CONTINUE
      NGMIN=NGM
      JJ=NGMIN+(J-NGMIN)/2
      L=0
      DO 200 K=NGMIN,JJ
      LLL=J-L
      LL=XP(K)
      XP(K)=XP(LLL)
      XP(LLL)=LL
  200 L=L+1
      RETURN
      END
```

```
** 0

      SUBROUTINE Q(II,LL,F,ICNT,LINE)
C...GIVEN II AND LL AS BOUNDS OF PARTITION
C...THE PARTITION IS PARTITIONED
C...F RETURNS AS PARTITION POINT
      REAL VL(10)
      INTEGER CP(4),CRIT(12)
      INTEGER AVL(10),BVL(10)
      INTEGER LINE(20),F,COMM(165),FLPTR(4),STURC(340)
      COMMON COMM,FLPTR,STURC,IERFL
      COMMON CP,CRIT
      EQUIVALENCE (COMM(20),ICM20),(COMM(29),ICM29),(COMM(19),ICM19)
      EQUIVALENCE (COMM(132),KBLNK)
      MOFL=ICM19+ICM20
      MOVFL=MOFL+ICM29
      I=II
      L=LL
      F=II
      IFLAG=1
      CALL IRTRV(ISCWD,I,2)
      CALL RMASR(ISCWD)
      CRIT(2)=CRIT(2)+1
      IP=1
      DO 100 N=1,ICNT
      NF=LINE(N)
      IF(NF-MOFL)75,75,80
   75 VL(N)=GFLD(NF)
      GO TO 100
   80 GO TO(85,100),IP
C...IP IS USED TO INSURE ONLY 1 STRING FIELD IS USED FOR SORT
   85 NF=NF-MOFL
      IF(NF-ICM29)90,90,100
   90 LK=6
      CALL GVBLF(NF,AVL,LK)
      IF(LK-6)93,98,98
   93 LK=LK+1
      DO 95 MM=LK,6
   95 AVL(MM)=KBLNK
   98 IP=2
  100 CONTINUE
      NR=L
      NRR=I
  400 CALL IRTRV(LSCWD,NR,2)
      CALL RMASR(LSCWD)
      CRIT(2)=CRIT(2)+1
      IP=1
      DO 200 N=1,ICNT
      NF=LINE(N)
      IF(NF-MOFL)150,150,160
  150 IF(VL(N)-GFLD(NF))151,200,155
  151 IF(IFLAG)300,200,200
  155 IF(IFLAG)200,200,300
  160 LK=6
      GO TO(161,200),IP
  161 NF=NF-MOFL
      IF(NF-ICM29)162,162,200
  162 CALL GVBLF(NF,BVL,LK)
      IP=2
      IF(LK-6)165,175,175
  165 LK=LK+1
      DO 170 MM=LK,6
  170 BVL(MM)=KBLNK
  175 DO 180 MM=1,6
      IF(AVL(MM)-BVL(MM))151,180,155
  180 CONTINUE
  200 CONTINUE
      IF(IFLAG)210,210,220
  210 I=I+1
      NR=I
      GO TO 230
```

```
  220 L=L-1
      NR=L
  230 IF(L-I)999,999,400
C...INTERCHANGE
  300 CONTINUE
      CRIT(1)=CRIT(1)+1
      CALL IRTRV(LSCWD,NRR,1)
      IFLAG=-IFLAG
      IF(IFLAG)310,310,320
  310 I=I+1
      F=L
      NR=I
      NRR=L
      GO TO 230
  320 L=L-1
      F=I
      NR=L
      NRR=I
      GO TO 230
  999 CALL IRTRV(ISCWD,F,1)
      RETURN
      END
```

** PTCAL

```
      SUBROUTINE PTCAL(NSW,L,NXSW)
C...NSW IS A SECTOR/WORD BLOCK POINTER
C...NXSW WILL BE THE SEC/WD POINTER L WORDS FARTHER ON IN THE DISK
      NS=IGVB(NSW,0,11)
      NW=IGVB(NSW,12,15)
      J=NW+L/20
      JJ=J/16
      NXS=NS+JJ
      NXW=J-16*JJ
      NXSW=IPVB(NXS,NXW,0,11)
      RETURN
      END
```

** RCATC

```
      SUBROUTINE RCATC
      INTEGER COMM(165),FLPTR(4),STORC(340),BUFF(41)
      COMMON COMM,FLPTR,STORC,IERFL,BUFF
      EQUIVALENCE (KARD,COMM(34))
C...READ CATEGORY CARD
C...ADVISOR NO. IN BUFF(1)
C...ADVISOR NAME IN A2 IN BUFF(2)-(11)
C...EOD FLAG IN A1 IN BUFF(41). USE '*'
    1 READ(KARD,900)(BUFF(I),I=1,11),BUFF(41)
  900 FORMAT(I3,T10,10A2,T80,A1)
      RETURN
      END
```

```
** RDSCC

      SUBROUTINE RDSCC
      INTEGER FIELD(15)
      INTEGER COMM(165),FLPTR(4),STURC(340),BUFF(41)
      INTEGER BUFF2,BUFF3,BUFF9,BFF10
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (BUFF(2),BUFF2),(BUFF(3),BUFF3),(BUFF(9),BUFF9),
     +            (BUFF(10),BFF10)
      EQUIVALENCE (KARD,COMM(34))
      EQUIVALENCE (BUFF(41),KEST),(BUFF(8),KDAT)
      EQUIVALENCE (KD,BUFF(4)), KID,BUFF 1
      EQUIVALENCE (KN,BUFF(5)),(KS,BUFF(6))
      DATA FIELD/16,16,3,6,9,8,6,8,8,8,4,7,16,16,13/
      DATA KDASH/'-'/
      DATA KAST/'*'/
C...READ A DESCRIPTOR CARD
    1 READ(KARD,900)(BUFF(I),I=4,8),(BUFF(I),I=11,15),(BUFF(I),I=16,36)
     +     ,KEST
  900 FORMAT(6X,T28,I2,T35,I3,A1,I2,T55,I3,T41,I1,T53,I2,T75,A2,A2,T27,
     +       I1,T7,8A2,T58,8A2,T42,5A2,T80,A1)
      IF(KEST-KAST)10,39,10
   10 IF(KEST-KDASH)11,20,11
   11 CALL ERR(1)
   12 CONTINUE
      CALL STACK
      GO TO 1
   20 CONTINUE
      BUFF2=0
      BUFF3=0
      BUFF9=0
      IF(KDAT-400)25,25,27
   25 KDAT=KDAT-150
      GO TO 30
   27 KDAT=KDAT-470
   30 KID    =IPVB(KD,0,0,5)+KN+KS
      BFF10=200
C...NOW PACK FIELDS
C...BUFF(1) & (2) ALREADY SET UP.
      KCNT=32
      IFLD=3
      KS=IPVB(IGVB(KS,0,7),0,8,15)
  110 IFRST=KCNT
      K=BUFF(IFLD)
      ILAST=KCNT+FIELD(IFLD)-1
      KCNT=ILAST+1
      IFWD=IFRST/16+1
      ILWD=ILAST/16+1
      IFBT=IFRST-(IFWD-1)*16
      ILBT=IL  T-(ILWD-1)*16
      IF(IFWD-LWD)130,120,120
  120 BUFF(IFWD)=IPVB(K,BUFF(IFWD),IFBT,ILBT)
  121 IF(IFLD-15)125,1100,1100
  125 IFLD=IFLD+1
      GO TO 110
  130 K1=ILBT-IFBT+17
      K2=15-ILBT
      BUFF(ILWD)=IPVB(IGVB(K,K2,15),BUFF(ILWD),0,ILBT)
      K1=16-K1
      K2=K2-1
      BUFF(IFWD)=IPVB(IGVB(K,K1,K2),BUFF(IFWD),IFBT,15)
      GO TO 121
C...PUT ALPHA FIELDS IN
 1100 DO 1110 I=16,36
 1110 BUFF(I-7)=BUFF(I)
      GO TO(39,12),IERFL
   39 RETURN
      END
```

```
** RDMDC

      SUBRCUTINE RDMDC
      INTEGER CCMM(165),BUFF(41),STURC(340),FLPTR(4)
      COMMON CCMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (BUFF(1),I1),(BUFF(2),I2),(BUFF(3),I3)
C...READ A MODIFICATION CARD
      I1=0
      I2=0
      I3=15
      K=ICM19+6
      READ(NCRD,900)(BUFF(I),I=7,K)
  900 FORMAT(2I3,T76,I1,T30,I1,T28,2I1,T68,2I1,T31,2I2,T62,2I2,T38,2I3,
     +  2I4,2I3,I1,I2,T76,I1,T61,I1,T76,I1)
      BUFF(9)=0
      DO 10 I=10,16
      IF(BUFF(I) )10,10,5
    5 IM1=I-1
      I1=IPV8(1,I1,IM1,IM1)
   10 CONTINUE
      DO 20 I=17,K
      IF(BUFF(I))20,20,15
   15 IM1=I-17
      I2=IPV8(1,I2,IM1,IM1)
   20 CONTINUE
      END
```

```
** RECMV

      SUBROUTINE RECMV(ISCWD,K)
C...ISCWD IS THE CURRENT SEC/WD POINTER TO RECORD
C...K IS RECORD NO. OF INDEX ENTRY
C...ON RETURN ISCWD WILL BE NEW POINTER
      INTEGER COMM(165),FLPTR(4),S(10),BUFF(41),DOLSL,SZMAS,
     +        LSTCL(10),MPT(30),CSPTR(4),STURC(340)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (IDIV,COMM(24))
      EQUIVALENCE (CSPTR(1),ICP)
      EQUIVALENCE (CSPTR(1),MPT(1))
      EQUIVALENCE (COMM(28),ICM28)
      EQUIVALENCE (STURC(8),IST8),(STURC(9),IST9)
      EQUIVALENCE(SZMAS,COMM(3)),(IDSCH,COMM(6)),(MFXF,COMM(19)),
     +           (NOFLD,COMM(21)),(IOPF,COMM(20)),(IDAT,COMM(36)),
     +           (IEND,COMM(1)),(INXF,COMM(2)),(INCRM,COMM(18))
      DATA DOLSL/'$'/
      IERFL=1
C...SAVE OLD LENGTH. CALCULATE NEW LENGTH
      LN=GFLD(3)
      NN=LN+INCRM
C...MAKE SURE LENGTH NOT TOO GREAT
      IF(NN-320)10,10,5
    5 CALL ERR(38)
      IERFL=2
      GO TO 999
C...SAVE 10 WORDS OF STURC. FREE OLD AREA.
   10 DO 11 I=1,10
      S(I)=STURC(I)
   11 STURC(I)=DOLSL
C...SAVE POINTERS FOR OLD AND NEW LOCATIONS
      NEWPT=IEND
C...CALC POINTERS
      IENDS=IGVB(IEND,0,11)
      IENDW=IGVB(IEND,12,15)
      IST8=LN
      IST9=INXF
      CALL WMASR(ISCWD,LN)
C...RESTORE FIRST 10 WORDS
      DO 15 I=1,10
   15 STURC(I)=S(I)
C...PUT IN NEW LENGTH
      CALL IPFLD NN,X,3
C...ZERO OUT THE NEW WORDS.
      N1=LN+1
      DO 20 I=N1,NN
   20 STURC(I)=0
C...SET FREE AREA WORDS
      N1=NN+1
      NN=NN+7
      DO 30 I=N1,NN
   30 STURC(I)=DOLSL
      IF(IENDS-SZMAS+100)35,37,37
   35 STURC(NN+1)=32000
      GO TO 40
   37 STURC(NN+1)=(SZMAS-IENDS-1)*320
   40 STURC(NN+2)=0
      STURC(NN+3)=0
C...PUT RECORD ON DISK WITH 10 WORDS OF FREE AREA
      CALL WMASR(IEND,1)
      GO TO(50,45),IERFL
   45 IERFL=2
      GO TO 999
   50 CONTINUE
C...SAVE NEW POINTER
      ISV=IEND
C...UPDATE INDEX
      READ(S'K)ID1,ID2,ID3
      WRITE(S'K)ID1,ID2,ID3,IEND
C...UPDATE FREE AREA POINTERS IN COMM
```

```
      IENDW=IENDW+NN/20
      I=IENDW-16
      IF(I)60,55,55
   55 IENDS=IENDS+1
      IENDW=I
   60 IEND=IPVB(IENDS,IENDW,0,11)
      INXF=ISCWD
C...UPDATE CATEGORY CHAIN
      KADV=GFLD(ICM28)
      READ(2'KADV)IPT
      CALL INVRT(2,IPT,12,ISCWD,NEWPT,MPT)
      GO TO(125,80),IERFL
   80 WRITE(1,901)KADV
  901 FORMAT('CATEG. ',I4)
      IERFL=1
  125 CONTINUE
C...SAVE COURSES AND CHAINS
C...CALCULATE POINTER TO LAST FIELD
      NFC=NFXF+ICPF+1
      IG=GFLD(4)
      IFELD=NFC+IG*NCFLD-1
C...IFELD SHOULD HAVE NO. OF DATE FIELD IN LAST GROUP
  118 ISWCH=1
      ICNT=0
  119 KDAT=GFLD(IFELD)
      IF(IDAT-KDAT)1125,120,1125
  120 ICNT=ICNT+1
      I1=GFLD(IFELD-5)
      I2=GFLD(IFELD-4)
      I3=GFLD(IFELD-3)
      I3=IPVB(I3,64,0,7)
      LSTCL(ICNT)=IPVB(I1,I2,0,5)+I3
      IFELD=IFELD-NCFLD
      IF(ICNT-10)119,119,122
  122 ISWCH=2
 1125 CONTINUE
      DO 180 I=1,ICNT
      KID=LSTCL(I)
      CALL HSHF1(KID,IR,IDIV,2,CSPTR)
      IF(IR)130,130,135
  135 CONTINUE
      IPT=ICP
      CALL INVRT(3,IPT,30,ISCWD,NEWPT,MPT)
      GO TO(180,130),IERFL
  130 CONTINUE
      WRITE(1,902)KID
  902 FORMAT('DESC. ', I6)
  180 CONTINUE
      GO TO(185,118),ISWCH
  185 CONTINUE
  990 ISCWD=ISV
  999 RETURN
      END
```

```
** RMASC

      SUBROUTINE RMASC
      INTEGER BUFF(41),COMM(165),FLPTR(4),STURC(340),STUD(41)
      INTEGER CHAR(40)
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (COMM(19),ICM19)
      EQUIVALENCE (NCRD,COMM(34)),(KHSH,BUFF(39)),(CHAR(1),COMM(126))
      DATA KAST/'*'/,KDASH/'-'/
C...THIS READS A MASTER CARD WITH DATA FOR MAND. BLOCK
C...AND FIRST VARIABLE SUBFIELD.  THIS IS A LOCAL ROUTINE
      K=ICM19+1
      DO 5 I=K,41
    5 BUFF(I)=0
      CALL SAVE
   10 READ NCRD,90 I79,I80
   90 FORMAT(T79,2A1)
      IF(I80-KAST)20,450,20
   20 IF(I79-KDASH)30,40,30
   30 CALL ERR(15)
      CALL STACK
      GO TO 10
   40 CALL RREAD
      READ(NCRD,900)STUD
C...NEED TO MAKE FORMAT MATCH LOCAL CARDS
  900 FORMAT(2I3,21A1,T28,3I1,2I2,I1,I2,2I3,2I4,2I3,2(I1,I2),I1)
      BUFF(41)=STUD(41)
      BUFF(5)=STUD(1)
      BUFF(6)=STUD(2)
      BUFF(7)=0
C...BUFF(9) WILL BE SET = STUD ENTRY FOR PLACES WITH 3-FIELD ID NO.
C...  BUFF(39) USED FOR NAME HASH
      KHSH=0
      DO 50 I=3,15,2
   50 KHSH=KHSH+STUD(I)
      DO 60 I=31,38
   60 BUFF(I-14)=STUD(I)
      BUFF( 8)=STUD(26)
      BUFF( 9)=STUD(24)
      BUFF(10)=STUD(25)
      BUFF(11)=0
      BUFF(12)=0
      BUFF(13)=STUD(27)
      BUFF(14)=STUD(28)
      BUFF(15)=STUD(40)
      BUFF(16)=0
      BUFF(25)=0
      BUFF(26)=STUD(39)
      BUFF(27)=0
      BUFF(28)=0
C...NOW PUT NAME IN A3 FORM INTO BUFF(31) THRU BUFF(37)
C...USE BUFF(38) FOR WORD COUNT FOR NAME
      CALL A1A3(STUD,3,23,BUFF,31,CHAR)
      DO 70 I=1,21
      II=24-I
      IF(STUD(II)-16448)80,70,80
   70 CONTINUE
   80 BUFF(38)=(II-1)/3
      RETURN
  450 IERFL=2
      RETURN
      END
```

```
** RMVBC

      SUBROUTINE RMVBC
      INTEGER COMM(165),FLPTR(4),STURC(340),BUFF(41)
      INTEGER SG(18),BUFF7,BUFF9,BFF40,BUFF8
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (COMM(6),ICM6),(KARD,COMM(34)),(BUFF(7),BUFF7),
     +            (BUFF(41),KECD),(BUFF(8),BUFF8),(BUFF(9),BUFF9)
      DATA IS/1/,KAST/'**'/
C...A LOCAL ROUTINE TO READ CARDS WITH
C...CATA TO MODIFY GROUPS AT END OF RECORD
      GO TO (10,50),IS
   10 IS=2
      ICM6=1
C.....READ GRADE SYMBOLS
      DO 800 I=1,18
      II=I+32
  800 READ(9'II)SG(I)
      BUFF9=0
   50 READ(KARD,900)(BUFF(I),I=1,7),KECD
      BFF40=2
  900 FORMAT(2I3,T77,I1,T28,I2,T35,I3,A1,T42,A2,T80,A1)
      IF(KECD-KAST)52,99,52
   52 DO 60 I=1,18
      IF(SG(I)-BUFF7)60,70,60
   60 CONTINUE
      CALL ERR(20)
      CALL STACK
      GO TO 50
   70 BUFF8=I-9
      BUFF7=5
   99 RETURN
      END
```

** RVBLC

```
      SUBROUTINE RVBLC
      INTEGER  BUFF(41),STURC(340),FLPTR(4),COMM(165),SG(18)
      INTEGER BUFF7,BUFF9,BUFF4,BUFF5,BUFF6,BFF10
      COMMON COMM,FLPTR,STURC,IERFL,BUFF
      EQUIVALENCE (BUFF(41),KC),(BUFF(4),BUFF4),(BUFF(10),BFF10)
      EQUIVALENCE (NCRD,COMM(34)),(BUFF(20),SG(1)),(COMM(36),ICM36),
     +           (BUFF(9),BUFF9),(BUFF(7),BUFF7),(COMM(6),ICM6),
     +           (BUFF(5),BUFF5),(BUFF(6),BUFF6)
      DATA KAST/'*'/
      DATA KS/1/
C...READS A CARD WITH GROUP DATA
      GO TO(10,100),KS
   10 CALL ERR(5)
      READ(6,902)IDT
  902 FORMAT(I3)
      IF(IDT-400)15,15,20
   15 IDT=IDT-150
      GO TO 25
   20 IDT=IDT-470
   25 DO 30 I=33,50
   30 READ(9'I)SG(I-32)
      KS=2
      ICM6=2
      BFF10=IDT
      ICM36=IDT
  100 CONTINUE
C...TESTS SHOULD BE MADE TO BE SURE CARD IS RIGHT TYPE
C...DONT LET THIS PROGRAM BE IN AN OVERLAY
      READ(NCRD,900)(BUFF(I),I=1,3),(BUFF(I),I=5,9),KC
  900 FORMAT(2I3,T78,I1,T28,I2,T35,I3,A1,I2,T42,A2,T80,A1)
      IF(KC-KAST)2,99,2
    2 CONTINUE
      DO 120 I=1,17
      IF(SG(I)-BUFF9)120,125,120
  120 CONTINUE
  125 BUFF9=I
      BUFF4=IPVB(BUFF5,BUFF6,0,5)+BUFF7
C...SECTION CODE MUST BE MOVED OVER TO BE ABLE TO FIT IN
C...8 BITS FOR IPFLD.
      BUFF7=IGVB(BUFF7,0,7)
C...PUT IN ANY OTHER SPECIAL PROCESSING NEEDED
   99 RETURN
      END
```

** RMASR

```
      SUBROUTINE RMASR(ISW)
      INTEGER COMM(165),FLPTR(4),STORC(340)
      COMMON COMM,FLPTR,STORC,IERFL
      EQUIVALENCE(IF1,FLPTR(1)),(K1,FLPTR(2)),(IF2,FLPTR(3)),
     +           (K2,FLPTR(4))
C...FIRST GET PROPER FILE AND SECTOR IN PHYSICAL FILES
    5 IS=IGVB(ISW,0,11)
      IW=IGVB(ISW,12,15)
      CALL DRIVE(IS,IW)
      GO TO (200,210),IERFL
  200 IRN=320-IW*20
  208 READ(IF1'K1)(STORC(I),I=1,IRN)
      IRN=IRN+1
      READ(IF2'K2)(STORC(I),I=IRN,340)
  210 RETURN
      END
```

** SHLL2

```
      SUBROUTINE SHLL2(IFREX,N)
      INTEGER IFREX(2,1)
C...SORT RCUTINE USED IN GARBG.  SORTS THE
C...ARRAY OF FREE AREA POINTERS INTO ASCENDING ORDER
      M=0
    5 M=M+M+1
      IF(M-N)5,20,20
   20 M=M/2
      IF(M)70,70,30
   30 K=N-M
      DO 60 J=1,K
      I=J
   40 L=I+M
      IF(IFREX(1,I)-IFREX(1,L))60,45,50
   45 IF(IFREX(2,I)-IFREX(2,L))60,60,50
   50 KEMP1=IFREX(1,I)
      KEMP2=IFREX(2,I)
      IFREX(1,I)=IFREX(1,L)
      IFREX(2,I)=IFREX(2,L)
      IFREX(1,L)=KEMP1
      IFREX(2,L)=KEMP2
      I=I-M
      IF(I)60,60,40
   60 CONTINUE
      GO TO 20
   70 RETURN
      END
```

```
** SHOVE

      SUBROUTINE SHOVE(ICUT,IDISP)
      INTEGER COMM(165),FLPTR(4),STORC(340)
      COMMON COMM,FLPTR,STORC,IERFL
      EQUIVALENCE (STORC(1),IST)
      EQUIVALENCE (COMM(15),ICM15),(COMM(14),ICM14),(COMM(16),ICM16)
C...
C...ICUT IS POINT AT WHICH SPACE IS TO BE PROVIDED.  IDISP IS SIZE OF
C...SPACE.  CURRENT LENGTH IS L.  LA IS CURRENT ACTIVE LENGTH.
      L=GFLD(3)
      LA=ICM14+ICM15*IGVE(IST,0,0)+GFLD(2)+ICM16*GFLD(4)
      IF(L-LA-IDISP)20,50,50
   20 IERFL=2
      RETURN
   50 LAI=LA+IDISP
      N=LA-ICUT+1
      IF(IDISP)45,400,50
   40 K=1
      GO TO 55
   45 K=-1
      LA=ICUT
      LAI=LAI+IDISP
      DO 60 I=1,N
      STORC(LAI)=STORC(LA)
      LAI=LAI+K
      LA=LA+K
   60 CONTINUE
  400 RETURN
      END
```

** STATS

```
      SUBROUTINE STATS
      INTEGER COMM(165),FLPTR(4),STORC(340),OP(4),CRIT(12),IVAL(50),
     +        SPTR,LINE(15)
      REAL SUM(3),SSUM(3),MAX(3),MIN(3)
      COMMON COMM,FLPTR,STORC,IERFL,OP,CRIT,IVAL,SPTR
      DATA KBLNK,KCOMMA/' ',','/
C...GATHERS STATISTICS ON RECORDS POINTED TO BY WORKING SET.
C...SET TO GIVE STATS ON  1 TO 3 FIELDS
      CALL ERR(61)
      READ(6,901)LINE
  901 FORMAT(15A1)
      J=0
      DO 10 I=1,15
      L=LINE(I)
      IF(L-KBLNK)4,10,4
    4 IF(L-KCOMMA)5,10,5
    5 CALL FIELD(LINE,I,NF)
      IF(NF)15,15,7
    7 J=J+1
      LINE(J)=NF
      IF(J-3)10,20,20
   10 CONTINUE
   15 IF(J)99,99,20
   20 IF(SPTR)25,25,30
   25 CALL ERR(57)
      GO TO 99
   30 CONTINUE
      DO 35 I=1,3
      SUM(I)=0.0
      SSUM(I)=0.0
      MIN(I)=99999.0
   35 MAX(I)=-99999.0
      KNT=0
      DO 100 I=1,SPTR
      CALL IRTRV(ISCWD,I,2)
      IF(ISCWD)40,100,40
   40 CALL RMASR(ISCWD)
      KNT=KNT+1
      DO 50 K=1,J
      X=GFLD(LINE(K))
      SUM(K)=SUM(K)+X
      SSUM(K)=SSUM(K)+X*X
      IF(MIN(K)-X)45,45,43
   43 MIN(K)=X
   45 IF(MAX(K)-X)47,50,50
   47 MAX(K)=X
   50 CONTINUE
  100 CONTINUE
      XNT=KNT
      DO 110 I=1,J
      A=SUM(I)/XNT
      SD=SQRT(SSUM(I)/XNT-A*A)
      WRITE(1,903)LINE(I)
  903 FORMAT('FIELD ',I2,/)
      WRITE(1,904)SUM(I),A,SD,MAX(I),MIN(I)
  904 FORMAT('SUM=',E13.6,2X,'AVE=',E13.6,2X,'S.D.=',E13.6,2X,'MAX=',
     +       E13.6,2X,'MIN=',E13.6,//)
  110 CONTINUE
   99 RETURN
      END
```

```
** WWASR

      SUBROUTINE WWASR(ISW,KEY)
      INTEGER COMM(165),FLPTR(4),STURC(340)
      INTEGER GLPTR(4),S(320)
      COMMON COMM,FLPTR,STURC,IERFL
      EQUIVALENCE (IF1,GLPTR(1)),(KSC1,GLPTR(2)),(IF2,GLPTR(3)),
     +            (KSC2,GLPTR(4)),(S(1),STURC(1))
C...THIS WRITES THE MASTER RECORD CURRENTLY IN STURC BACK ON THE DISK.
C...IF KEY=0 EXACTLY STURC(1)-(LENGTH OF REC) IS WRITTEN.  IF KEY=1 THE
C...THE 10 NEXT WORDS ARE WRITTEN. IF KEY.GT.1 THE NO. WORDS WRITTEN=KEY
      IS=IGVB(ISW,0,11)
      IW=IGVB(ISW,12,15)
      CALL DRIVE(IS,IW)
      DO 5 I=1,4
    5 GLPTR(I)=FLPTR(I)
      GO TO (200,210,210),IERFL
  200 NWDS=GFLD(3)+10*KEY
      IF(KEY-1)201,201,220
  220 NWDS=KEY
  201 IRN=320-IW*20
      ISWCH=1
      IF(NWDS)212,210,211
  211 IF(NWDS-340)213,213,212
  212 WRITE(IF1'KSC1)S
      GO TO 210
  213 IF(NWDS-IRN)202,202,206
  202 IRN=NWDS
      ISWCH=2
  206 WRITE(IF1'KSC1)(STURC(I),I=1,IRN)
      GO TO(207,210),ISWCH
  207 IRN=IRN+1
      WRITE(IF2'KSC2)(STURC(I),I=IRN,NWDS)
  210 RETURN
      END
```

APPENDIX E

PROGRAM LISTINGS FOR SCRIPT

The main programs for initializing files, adding new lessons to the disk file, and polling the terminals are given first followed by the subprograms.

The listing for IPVB/IGUB is given in the listings for STRIPE. The interrupt level subroutine, ILSØ3, and the interrupt response and utility routine, LMCC, are not listed here since they come from Logicon,Inc.

```
** INIT

      INTEGER MESS(64),BUFF(64),ZB(20),Z(5)
      EQUIVALENCE (ZB(1),Z(1))
      DATA LF,KR/Z000A,Z000D/
      DEFINE FILE 2(6400,1,U,N2),1(100,32,U,N1),6(32,10,U,N6)
      DEFINE FILE 3(64, 5,U,N3),4(48,20,U,N4),5(32,10,U,N5)
C...GET CHAR CODES
  100 READ(2,902)(MESS(I),I=2,63)
  902 FORMAT(63A1)
      MESS(1)=62
      CALL EBTTY(MESS,BUFF(63))
      DO 110 I=1,30
      J=63-I
  110 MESS(I)=BUFF(J)
      MESS(29)=4
      MESS(28)=LF
      MESS(27)=KR
      WRITE(6'3)(MESS(I),I=1,30)
      DO 150 K=7,30
      READ(2,902)(MESS(I),I=2,63)
      IF(MESS(2)-23616)125,200,125
  125 MESS(1)=20
      CALL EBTTY(MESS,BUFF(64))
      DO 128 I=2,63
      IF(MESS(I)-16448)128,126,128
  126 IF(MESS(I+1)-16448)128,127,128
  127 KNT=I
      GO TO 129
  128 CONTINUE
  129 CONTINUE
      IP=65-KNT
      BUFF(IP)=LF
      BUFF(IP-1)=KR
      BUFF(IP-2)=4
      DO 130 I=1,10
      II=11-I
      III=65-2*I
  130 MESS(II)=IPVB(BUFF(III),BUFF(III-1),0,7)
  150 WRITE(6'K)(MESS(I),I=1,10)
  200 DO 220 I=1,20
  220 ZB(I)=0
      DO 230 I=1,16
  230 WRITE(3'I)ZB
      DO 250 I=1,31,2
  250 WRITE(5'I)ZB
      Z(1)=10
      Z(3)=0
      Z(4)=0
      WRITE(6'1)Z
      CALL EXIT
      END
// XEQ          1
*FILES(1,MESS),(2,DCTBL),(3,INDX),(4,PARTS),(5,TCHR),(6,SYSF)
0123456789HRELSC$+-*/ .
TIME LIMIT
RETYPE RESPONSE
NOT IMPLEMENTED
READY. TYPE  ID
LOGGED OFF
TYPE 1 TO BEGIN
OUT OF RANGE
ID NO. IN USE
CAN'T INTERPRET
*
```

```
** ADLSN

      INTEGER MSSNM(20),MESS(64),BUFF(64)
      DATA LF,KR/Z000A,Z000D/
      DEFINE FILE 2(6400,1,U,N2),1(100,32,U,N1),6(32,10,U,N6)
      DEFINE FILE 3(64, 5,U,N3),4(48,20,U,N4),5(32,10,U,N5)
      READ(6'1)ITL,INDXP,KPDTB,KPMSG
      INDXP=INDXP+1
      K1=KPDTB+1
      K2=KPMSG+1
C...PUT IN MESSAGE VECTOR
   15 READ(2,922)MSSNM
  922 FORMAT(20I4)
      DO 20 I=1,20
      K=MSSNM(I)
      IF(K)30,30,25
   25 CONTINUE
      KPDTB=KPDTB+1
      WRITE(2'KPDTB)MSSNM(I)
   20 CONTINUE
      GO TO 15
   30 LMV=KPDTB-K1+1
C...PUT IN DECISION TABLE
      READ(2,900)IR,IC
  900 FORMAT(2I4)
      NREC=IR*IC
      DO 10 I=1,NREC
      READ(2,901)NS,NCM,IPTR
  901 FORMAT(3I4)
    5 K=IPVB(NS,0,0,5)+IPVB(NCM,0,6,8)+IPTR-1
      KPDTB=KPDTB+1
      WRITE(2'KPDTB)K
   10 CONTINUE
C...PUT IN MODUL MESSAGES
   51 READ(2,902)(MESS(I),I=2,63)
  902 FORMAT(63A1)
      IF(MESS(2)-23616)52,100,52
   52 DO 60 I=2,61
      IF(MESS(I)-16448)60,55,60
   55 IF(MESS(I+1)-16448)60,65,60
   60 CONTINUE
      I=61
   65 MESS(1)=I+1
      CALL EBTTY(MESS,BUFF(64))
      K=65-I
      BUFF(K)=LF
      BUFF(K-1)=KR
      BUFF(K-2)=4
      I=(I+2)/2
      DO 75 L=1,I
      K=64-L
      KK=65-2*L
      KKK=KK-1
   75 BUFF(K)=IPVB(BUFF(KK),BUFF(KKK),0,7)
      KPMSG=KPMSG+1
      WRITE(1'KPMSG)(BUFF(I),I=33,64)
      GO TO 51
  100 CONTINUE
      WRITE(3'INDXP)IR,IC,K2,K1,LMV
      WRITE(6'1)ITL,INDXP,KPDTB,KPMSG
      CALL EXIT
      END
// XEQ          1
*FILES(1,MESS),(2,DCTBL),(3,INDX),(4,PARTS),(5,TCHR),(6,SYSF)
   1   2   6   3   9   2   7   4   5  10   8  11
   3   4
   2   2   1
   2   2   1
   1   1  12
   3   1   3
   4   3   4
```

```
    2    1   12
    3    3    7
    4    3    4
    3    1   12
    1    1   10
    1    1   11
    4    1   12
ZWEI UND ZWEI IST FUNF. NICHT WEHR
1) JA 2) NEIN
DU HAST RECHT. DO YOU WANT THE NEXT LESSON
DIESE IST VIER. XXXX
DIESE IST FUNF. XXXXX
VERSUCHE BITTE WIEDER
ACH. DU LIEBER.LERNE ZAHLEN. VERSUCHE WIEDER.
DAS IST ALLES.
DO YOU WANT THE NEXT LESSON
THEN REQUEST MODULE 2.
NO HELP NEEDED
*
```

```
** POLL

      INTEGER TE(64,8),TP(15,8),ISYS(20),MOD( 500),STAT,TIME,DEV,
     +        CHAR(20)
      EXTERNAL USER
      COMMON TE,TP,ISYS,MOD,STAT,INTR,KNT,DEV,CHAR,TIME
      EQUIVALENCE (ISYS(1),ISYS1)
C...FILE ONE FOR MODULE MESSAGES.
C...FILE 2 FOR DECISION TABLES
C...FILE 3 FOR INDEX
C...FILE 4 FOR SAVING PARTITIONS
C...FILE 5 FOR TEACHER FILES
C...FILE 6 FOR SYSTEM PARAMETERS
      DEFINE FILE 1(100,32,U,N1),2(6400,1,U,N2),3(64,5,L,N3)
      DEFINE FILE 4(160,2,U,N4),5(32,10,U,N5),6(32,10,L,N6)
      CALL FIRST
      WRITE(1,500)
  500 FORMAT('ENTER MODULE NO. IN I2')
      READ(6,501)ID
  501 FORMAT(I2)
C...READ IN CHAR FROM DISK AND LOAD MODULE
C...THIS IS TEMPORARY
      CALL LOADD(ID)
      CALL LINIT(USER)
   30 CONTINUE
      CALL LTIME(TIME)
      DO 120 I=1,8
      CALL LMASK
      IF(IGVE(TP(1,I),0,0))50,50,80
   50 IF(ISENS( I))110,110,60
   60 CONTINUE
C...CHECK TO SEE IF DATA SET READY ALREADY SET
      IF(IGVE(TP(1,I),4,4))65,65,100
   65 TP(1,I)=IPVE(1,TP(1,I),4,4)
      TP(5,I)=1
      CALL LREAD(I)
      GO TO 110
   80 IT=TIME-TP(2,I)
      IT=-1
      IF(IT)100,100,85
   85 IF(IT-ISYS1)95,95,90
   90 CONTINUE
      CALL MESG(5,I)
      CALL LABLS(I)
      INTR=IPVE(0,INTR,II,II)
      TP(15,I)=3
      TP(5,I)=1
      TP(1,I)=0
      GO TO 110
   95 CONTINUE
      IF(IGVE(TP(1,I),3,3))96,96,100
   96 IF(IGVE(TE(64,I),7,7))100,100,97
   97 CALL MESG(1,I)
      TP(1,I)=IPVE(1,TP(1,I),3,3)
  100 CONTINUE
      II=I-1
      IF(IGVE(INTR,II,II))110,110,105
  105 DEV=I
      CALL SERV
  110 CONTINUE
      CALL LLINK
  120 CONTINUE
      GO TO 30
      END
```

** BREAK

```
      SUBROUTINE BREAK
      INTEGER TB(64,8),TP(15,8),ISYS(20),MOD( 500),STAT,TIME,DEV,
     +        CHAR(30)
      COMMON TB,TP,ISYS,MOD,STAT,INTR,KNT,DEV,CHAR,TIME
      EQUIVALENCE (ISYS(1),ISYS1)
      TP(2,STAT)=TIME+ISYS1
      IFL=TP(1,STAT)
      IF(IGVB(IFL,0,0))10,10,20
   10 CONTINUE
      I=STAT-1
      INTR=IPVB(1,INTR,I,I)
      TP(15,STAT)=2
      TP(1,STAT)=IPVB(1,IFL,0,0)
      I=0
      RETURN
   20 TB(64,STAT)=0
      I=1
      RETURN
      END
```

** CALC

```
      SUBROUTINE CALC
      REAL IVL1,IVL2
      INTEGER TB(64,8),TP(15,8),ISYS(20),MOD( 500),STAT,TIME,DEV,
     +        CHAR(30)
      INTEGER DOLR,BLNK
      COMMON TB,TP,ISYS,MOD,STAT,INTR,KNT,DEV,CHAR,TIME
      EQUIVALENCE (BLNK,CHAR(30)),(DOLR,CHAR(17)),(KE,CHAR(13))
      EQUIVALENCE (CHAR(20),K20)
      IP=63
      IB=1
      CALL NBLNK(IP,IB)
      KF=(IB-1)*8+1
      IOP=IGVB(TB(IP,DEV),KF,KF+6)
      DO 10 I=13,16
      IF(IOP-CHAR(I))10,5,10
    5 IOP=I-7
      IP=IP-2
      GO TO 64
   10 CONTINUE
   30 CALL KNUM(IP,IB,IVL1,IERR)
      GO TO (40,55),IERR
   40 CALL NBLNK(IP,IB)
      KF=1+(IB-1)*8
      IOP=IGVB(TB(IP,DEV),KF,KF+6)
      DO 50 I=18,21
      IF(IOP-CHAR(I))50,45,50
   45 IOP=I-17
      GO TO 60
   50 CONTINUE
   55 CALL MESG(9,DEV)
      RETURN
   60 IF(IB-2)62,61,61
   61 KF=1
      KL=7
      IP=IP-1
      IB=1
      GO TO 66
   62 KF=9
      KL=15
      IB=2
   66 IOP1=IGVB(TB(IP,DEV),KF,KL)
      IF(IOP1-K20      )64,63,64
   63 IOP=5
      GO TO 60
   64 CALL NBLNK(IP,IB)
      CALL KNUM(IP,IB,IVL2,IERR)
      GO TO(65,55),IERR
   65 GO TO(70,75,80,85,90,95,96,97,98),IOP
   70 RSLT=IVL1+IVL2
      GO TO 100
   75 RSLT=IVL1-IVL2
      GO TO 100
   80 RSLT=IVL1*IVL2
      GO TO 100
   85 RSLT=IVL1/IVL2
      GO TO 100
   90 RSLT=IVL1**IVL2
      GO TO 100
   95 RSLT=EXP(IVL2)
      GO TO 100
   96 RSLT=ALOG(IVL2)
      GO TO 100
   97 RSLT=SIN(IVL2)
      GO TO 100
   98 RSLT=COS(IVL2)
  100 CALL TRNSL(RSLT,DEV)
      CALL LWRIT(DEV)
      RETURN
      END
```

** FIRST

```
      SUBROUTINE FIRST
      INTEGER TB(64,8),TP(15,8),ISYS(20),MOD( 500),STAT,TIME,DEV,
     +        CHAR(30)
      COMMON TB,TP,ISYS,MOD,STAT,INTR,KNT,DEV,CHAR,TIME
C...GENERATE SYSTEM, SET MODULE PTRS TO NULL, ETC.
      INTR=0
      READ(6'1)ISYS
      READ(6'3)CHAR
      DO 20 J=1,8
      DO 10 I=1,14
   10 TP(I,J)=0
      TP(15,J)=1
      TP(9,J)=1
      DO 20 I=1,64
   20 TB(I,J)=0
      RETURN
      END
```

** ISENS

```
        ENT       ISENS
ISENS   DC        *-*
        LDX   I1  ISENS
        LD    I1  0
        S         K1
        STO       DEV
        A         SR
        STO       SHIFT
        LD        DEV
        SLA       3
        OR        MASK
        STO       IOCC+1
        XIO       IOCC
        AND       MASK1
SHIFT   NOP
        MDX   L   ISENS,1
        BSC   I   ISENS
        BSS   E   0
IOCC    DC        0
        DC        *-*
MASK    DC        /770I
MASK1   DC        /1111
DEV     DC        *-*
SR      SRA       0
K1      DC        1
        END
```

```
** KALM

      SUBROUTINE KALM(IF,IE, VAL,IERR)
      INTEGER KA(10)
      INTEGER TE(64,8),TF(15,8),ISYS(20),MCD( 500),STAT,TIME,DEV,
     +        CHAR(30)
      COMMON TE,TF,ISYS,MCD,STAT,INTR,KNT,DEV,CHAR,TIME
      EQUIVALENCE (CHAR(30),KELAK),(CHAR(10),K10),(CHAR(23),IFER)
C...USE IF FOR PTR TO WORD, IE FOR BYTE
      I=0
      IFLG=1
      IERR=1
      IF(IE-2)10,20,20
   10 KNT=IGVB(TE(IF,DEV),1,7)
      IB=1
      GO TO 50
   15 I=I+1
      KA(I)=KNT
   20 KNT=IGVB(TE(IF,DEV),9,15)
      IB=2
      GO TO 50
   25 I=I+1
      KA(I)=KNT
   30 IF=IF-1
      GO TO 10
   50 IF(IGVB(KNT,8,11)-3)60,55,60
   55 KNT=IGVB(KNT,12,15)
      GO TO (15,25),IB
   60 CONTINUE
      IF(KNT-IFER)62,61,62
   61 II=1
      IFLG=2
      GO TO (20,30),IB
   62 IF(I)65,65,70
   65 IERR=2
      RETURN
   70 VAL=0
      GO TO (76,76),IFLG
   76 II=I
   78 DO 80 J=1,II
   80 VAL=VAL*10+KA(J)
      GO TO(100,85),IFLG
   85 II=II+1
      K=-1
      DO 90 J=II,I
      VAL=VAL+KA(J)*10.0**K
   90 K=K-1
  100 RETURN
      END
```

```
** LDMOD

*ONE WORD INTEGERS
      SUBROUTINE LDMOD(ID)
      INTEGER TB(64,8),TP(15,8),ISYS(20),MOD( 500),STAT,TIME,DEV,
     +        CHAR(30)
      COMMON TB,TP,ISYS,MOD,STAT,INTR,KNT,DEV,CHAR,TIME
      EQUIVALENCE (MOD(1),MOD1),(MOD(2),MOD2),(MOD(3),MOD3),
     +            (MOD(4),MOD4)
      READ(3'ID)IR,IC,NMSG,IPTR,LMV
      K=IR*IC+LMV+4
      MOD1=IR
      MOD2=IC
      MOD3=NMSG-1
      MOD4=LMV+4
      READ(2'IPTR)(MOD(I),I=5,K)
      RETURN
      END
```

```
** MCOLL

      SUBROUTINE MCOLL(J)
      INTEGER MESS(32)
      INTEGER TB(64,8),TF(15,8),ISYS(20),MCO( 500),STAT,TIME,DEV,
     +        CHAR(30)
      COMMON TB,TF,ISYS,MCO,STAT,INTR,KNT,DEV,CHAR,TIME
      EQUIVALENCE (MESS(32),MSS64)
      EQUIVALENCE (MCO(1),IR),(MCO(2),IC),(MCO(3),MPT),(MCO(4),IPT)
C...USE TF(5,DEV) FOR CURR. STATE. J IS INPUT
C...THIS VERSION ASSUMES JUST ONE MCOLLE IN CORE
      NCM=TF(3,DEV)
      IF(NCM)10,10,100
   10 K=TF(5,DEV)
      IF(J)12,12,15
   12 J=IR
      GO TO 16
   15 IF(J-IR)16,16,16
   16 CALL MESG(7,DEV)
      RETURN
C...CALC. PTR TO (J,K) POSITION. ALLOW FOR FIRST 4 WORDS.
   16 K=(K-1)*IR+J+IPT
      K=MCO(K)
      NS=IGVE(K,0,5)
      TF(5,DEV)=NS
      NCM=IGVE(K,6,8)
      TF(3,DEV)=NCM
      K=IGVE(K,9,15)+5
C...NOW K WILL BE PTR TO MESSAGE VECTOR
      TF(4,DEV)=K
  100 K=TF(4,DEV)
      MSPTR=MCO(K)+MPT
      READ(1'MSPTR)MESS
      JR=MSS64-MSS64/2*2
      N=63-(MSS64-1)/2
      DO 20 I=N,63
   20 TB(I,DEV)=MESS(I-32)
      NCM=NCM-1
      K=K+1
      IF(NCM-1)50,30,30
   30 MSPTR=MCO(K)+MPT
      READ(1'MSPTR)MESS
C...PUTTING IN IDLE CHARS. AND OVERLAYING PREVIOUS ECT
      IF(JR)60,60,55
   55 TB(N,DEV)=4112
      GO TO 65
   60 TB(N,DEV)=IPVE(16,TB(N,DEV),8,15)
   65 TB(N-1,DEV)=4112
      N=N-2
      NN=N-30
      NL=0
      DO 40 I=NN,N
      NL=NL+1
   40 TB(I,DEV)=MESS(NL)
      NCM=NCM-1
      K=K+1
   50 CONTINUE
      CALL LWRIT(DEV)
      TF(3,DEV)=NCM
      TF(4,DEV)=K
      RETURN
      END
```

```
** NBLNK

      SUBROUTINE NBLNK(IP,IB)
      INTEGER BLNK
      INTEGER TB(64,8),TP(15,8),ISYS(20),MOD( 500),STAT,TIME,DEV,
     +        CHAR(30)
      COMMON TB,TP,ISYS,MOD,STAT,INTR,KNT,DEV,CHAR,TIME
      EQUIVALENCE (CHAR(30),BLNK)
C...THIS RCUTINE IS TC RETURN IP AND IB AS THE WORD AND BYTE
C...CF THE NEXT NCN-BLANK CHARACTER
      GO TC(21,16),IB
    5 K=IGVB(TB(IP,DEV),KF,KF+6)
      IF(K-BLNK)30,10,30
   10 GO TC(15,20),IB
   15 IB=2
   16 KF=9
      GO TO 5
   20 IB=1
      IP=IP-1
   21 KF=1
      GO TO 5
   30 RETURN
      END
```

** PSAVE

```
      SUBROUTINE PSAVE
      INTEGER TB(64,8),TP(15,8),ISYS(20),MOD( 500),STAT,TIME,DEV,
     +        CHAR(30)
      COMMON TB,TP,ISYS,MOD,STAT,INTR,KNT,DEV,CHAR,TIME
      ID= TP(5,DEV)
      WRITE(4'ID)TP(9,DEV)
      RETURN
      END
```

** PLOAD

```
      SUBROUTINE PLOAD
      INTEGER TB(64,8),TP(15,8),ISYS(20),MOD( 500),STAT,TIME,DEV,
     +        CHAR(30)
      COMMON TB,TP,ISYS,MOD,STAT,INTR,KNT,DEV,CHAR,TIME
      ID=TP(5,DEV)
      READ(4'ID)TP(9,DEV)
      RETURN
      END
```

** MESG

```
      SUBROUTINE MESG(IM,IDEV)
      INTEGER M(10)
      INTEGER TB(64,8),TP(15,8),ISYS(20),MOD( 500),STAT,TIME,DEV,
     +        CHAR(30)
      COMMON TB,TP,ISYS,MOD,STAT,INTR,KNT,DEV,CHAR,TIME
      READ(6'IM+6)M
      DO 20 I=1,10
      J=53+I
   20 TB(J,IDEV)=M(I)
      CALL LWRIT(IDEV)
      RETURN
      END
```

```
** SERV

      SUBROUTINE SERV
      INTEGER TB(64,8),TP(15,8),ISYS(20),MOD( 500),STAT,TIME,DEV,
     +        CHAR(30)
      INTEGER DCLR,BLNK
      COMMON TB,TP,ISYS,MOD,STAT,INTR,KNT,DEV,CHAR,TIME
      EQUIVALENCE (BLNK,CHAR(30)),(DCLR,CHAR(17)),(KE,CHAR(13))
      EQUIVALENCE (ISYS(1),ISYS1),(CHAR(22),ITIC)
C...ALSO USED FOR BUFFER OVFLO INTERRUPT
C...DETERMINE IF TERM. CHAR. CAME ON REC. OR XMIT MODES
C...S MUST PRECEDE ALL CONTROL RESPONSES
C...H RESPONSE FOR HELP
C...  C RESPONSE FOR CALCULATE MODE
C...   E RESPONSE FOR EXIT
C...    R RESPONSE FOR RETURN TO MODULE FROM CALCULATE MODE
C...     S RESPONSE TO SAVE STATE
C ....L RESPONSE TO LOAD SAVED STATE
C...FIND FIRST NON-BLANK AND EVALUATE
      CALL LTEST(DEV,IBUS)
      IF(IBUS)4,4,1010
    4 I=TP(15,DEV)
      GO TO(3,1,2),I
    1 CALL MESG(4,DEV)
      TP(15,DEV)=3
      GO TO 1000
    2 TP(15,DEV)=1
      GO TO 112
    3 IF(IGVB(TB(64,DEV),7,7))110,110,10
   10 CONTINUE
      DO 100 I=1,5
      II=64-I
      KHAR=IGVB(TB(II  ,DEV),1,7)
      IB=1
      IF(KHAR-BLNK)120,50,120
   50 KHAR=IGVB(TB(II  ,DEV),9,15)
      IB=2
      IF(KHAR-BLNK)120,100,120
  100 CONTINUE
  105 CALL MESG(2,DEV)
      GO TO 1000
  110 CONTINUE
      IF(TP(3,DEV))112,112,150
  112 CONTINUE
      TB(64,DEV)=0
      CALL LREAD(DEV)
      GO TO 1000
  120 IF(KHAR-ITIC)129,121,129
C...DETERMINE ID NO.
  121 IF(IB-2)122,123,123
  122 IB=2
      GO TO 124
  123 II=II-1
      IB=1
  124 CALL KNUM(II,IB, D,IERR)
      ID=D
C
      IF(IERR-2)128,127,127
  127 CALL MESG(9,DEV)
      GO TO 112
C
  128 DO 126 I=1,8
      IF(TP(5,I)-ID)126,125,126
  125 CALL MESG(8,DEV)
      GO TO 1000
  126 CONTINUE
      TP(5,DEV)=ID
      CALL MESG(6,DEV)
      GO TO 1000
  129 IF(KHAR-DCLR)130,200,130
  130 IF(IGVB(TP(1,DEV),1,2))135,135,131
```

```
  131 CALL CALC
      GO TO 1000
  135 DO 140 J=1,10
      I=J-1
      IF(KHAR-CHAR (J))140,150,140
  140 CONTINUE
      GO TO 105
C...MODUL IS TO FILL KBUF( ,DEV) WITH APPROP. MESSAGE. LEAVES ACC.=2
  150 CONTINUE
      CALL MODUL(I)
      GO TO 1000
C...CONTROL REQUEST
  200 GO TO(210,220),IB
  210 KHAR=IGVB(TB(II,DEV),9,15)
      GO TO 230
  220 KHAR=IGVB(TB(II-1,DEV),1,7)
  230 DO 237 I=11,16
      J=I-10
      IF(KHAR-CHAR(I))237,238,237
  237 CONTINUE
      GO TO 105
  238 GO TO(400,600,250,800,700,500),J
  400 I=0
      GO TO 150
C...EXIT ROUTINE NEEDS MORE WORK
C...SET DEVICE INACTIVE, ETC.
  250 TP(1,DEV)=0
      CALL LHANG(DEV)
      GO TO 1000
  500 TP(1,DEV)=IPVB(3,TP(1,DEV),1,2)
      GO TO 112
  600 TP(1,DEV)=IPVB(0,TP(1,DEV),1,2)
      GO TO 112
  700 CALL PSAVE
      GO TO 112
  800 CALL PLOAD
      GO TO 112
 1000 DEV=DEV-1
      INTR=IPVB(0,INTR,DEV,DEV)
 1010 RETURN
      END
```

** TERM

```
      SUBROUTINE TERM
      INTEGER TB(64,8),TP(15,8),ISYS(20),MOD( 500),STAT,TIME,DEV,
     +        CHAR(30)
      COMMON TB,TP,ISYS,MOD,STAT,INTR,KNT,DEV,CHAR,TIME
      EQUIVALENCE (ISYS(1),ISYS1)
      I=STAT-1
      INTR=IPVB(1,INTR,I,I)
      IF(IGVB(TB(64,STAT),7,7))10,10,20
   20 TP(2,STAT)=TIME+ISYS1
   10 CONTINUE
      I=0
      RETURN
      END
```

** TRNSL

```
      SUBROUTINE TRNSL(RR,I)
      INTEGER TB(64,8),TP(15,8),ISYS(20),MOD( 500),STAT,TIME,DEV,
     +        CHAR(30)
      COMMON TB,TP,ISYS,MOD,STAT,INTR,KNT,DEV,CHAR,TIME
      EQUIVALENCE (CHAR(29),KEOT),(CHAR(28),LF),(CHAR(27),KR)
      EQUIVALENCE (CHAR(30),KB),(CHAR(13),KE)
      EQUIVALENCE (CHAR(18),K18),(CHAR(19),K19),(CHAR(23),K23)
      R=RR
      ISIGN=K18
      IF(R)2,4,4
    2 ISIGN=K19
      R=-R
    4 ILX=-32
      IHX=32
    5 IMX=(ILX+IHX)/2
   10 IF(R-10.0**IMX)20,20,30
   20 IHX=IMX
      GO TO 35
   30 ILX=IMX
   35 IF(IHX-ILX-1)40,40,5
   40 R=R/10.0**ILX
      R=R+.000001
      K1=R
      R=(R-K1)*10.0
      K2=R
      R=(R-K2)*10.0
      K3=R
      R=(R-K3)*10.0
      K4=R
      R=(R-K4)*10.0
      K5=R
      R=(R-K5)*10.0
      K6=R
      TB(63,I)=IPVE(ISIGN,K23,0,7)
      TB(62,I)=IPVE(CHAR(K1+1),CHAR(K2+1),0,7)
      TB(61,I)=IPVE(CHAR(K3+1),CHAR(K4+1),0,7)
      TB(60,I)=IPVE(CHAR(K5+1),CHAR(K6+1),0,7)
      ISIGN=K18
      IF(IHX)45,50,50
   45 ISIGN=K19
      IHX=-IHX
   50 IH1=IHX/10
      IH2=IHX-10*IH1+1
      IH1=IH1+1
      TB(59,I)=IPVE(KE,ISIGN,0,7)
      TB(58,I)=IPVE(CHAR(IH1),CHAR(IH2),0,7)
      TB(57,I)=IPVE(KR,LF,0,7)
      TB(56,I)=IPVE(KEOT,0,0,7)
      RETURN
      END
```