Computer processing of the bibliographic records of a small library

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COMPUTER PROCESSING OF THE BIBLIOGRAPHIC RECORDS OF A SMALL LIBRARY

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ABSTRACT

A project has been conducted to automate the processing of the records associated with a small, restricted-access collection of undergraduate reading material in the Library of the University of Durham. The functions of a suite of programs written by the author for an IBM 360/67 computer, and now in regular use by the Library, are described. Through a simple command language, the (non-programmer) user may specify a wide variety of processes on files of bibliographic data as combinations of basic operations. He also has fine control over the layout of catalogues and other lists printed on the line-printer.

An account is given in this thesis of some of the problems which face those working on the automation of the maintenance of large library catalogues: conversion of old records to machine-readable form, filing catalogue entries and the role of computers in producing book catalogues. There is a discussion of programming and programming language in this context and a selection of new or improved features are suggested for incorporation in any future version of the Durham system. Full technical program documentation is supplementary to the thesis.

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COMPUTER USAGE IN DURHAM UNIVERSITY LIBRARY

1.1 *INTRODUCTION*

In the light of experience gained in writing and operating a set of computer programs, now obsolete, for maintaining the bibliographic file associated with the small Short Loan Collection of undergraduate reading material in Durham University Library, the author embarked on the creation of the software described in this thesis in February 1970. The Library's requirements were being serviced by means of the new programs by June of that year, although at that stage the system was usable only by the programmer. In September 1970 the command language was implemented, allowing a wide variety of jobs to be prepared with little effort (typically it takes 5-10 minutes per job, excluding card keypunching). Finally the documentation was written between January and July 1971, and consists of two parts; a user's manual*, much of which is reproduced here, and a technical program description[125], which is submitted with the thesis. Approximately 5 man-months was spent on program development and a similar quantity of effort was given to documentation. The system is designed to be operated entirely by library staff with little training in computing and the documentation was therefore an important facet of the system; it has yet (October 1971) to be proved.

Durham University owns, jointly with the University of Newcastle upon Tyne, an IBM 360 Model 67, known as NUMAC - The Northumbrian Universities Multiple Access Computer. The programs described here were written in PL/1 (Programming Language One) to run under the control of IBM System/360 Operating System. The on-line consoles attached to NUMAC are not used by the Library at present, all communication with the computer being through 80-column punched cards and line-printer.

The computer is being used to maintain files and produce lists for two small collections within the University Library. Both are closed access undergraduate collections, one of Arts and Social Sciences material (3000 items in October 1971), the other of Science literature (1000 items). There are also plans to establish a computer file for the recently acquired Collingwood research library (about 5000 items) in the Mathematics Department of the University.

The suite of programs which is now in regular use by the University Library is the major part of what is called the Library File Processing System (LFP System). This system is a tool for handling files of bibliographic records and

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*Oddy, R.N. "Computer Processing of Library Files at Durham University", Durham University Library Publication No.7: 1971

encompasses the organization and structure of files both inside and outside the machine, the computer programs which create, maintain and operate upon files and the means of using the programs. We summarize each of these three aspects in turn.

The Records

The following textual or coded information can be recorded in the files for each item in the library:

(i) Item number, an obligatory and unique record identification.

(ii) Type of publication (e.g. book, article, etc.).

(iii) Status (e.g. progress of order, temporary transfer from another collection, etc.).

(iv) Order details - agent, order and receipt dates, price, agent's report.

(v) Courses for which the item is recommended.

(vi) Authors, titles, class numbers.

(vii) Publisher and date of publication.

A record need not contain information of every type. The significance of the information is largely irrelevant to the mechanical processes in the system; some of the fields mentioned can be used for other purposes at the discretion of the library. The author, title, class number and publisher fields are of variable length, i.e. as long as the number of characters written into them. The remainder are fixed length fields, in which information either conforms to standard descriptions (e.g. prices or dates) or is codified (e.g. agent's reports, courses). The records are punched onto 80-column cards directly from forms prepared in the Library. The computer reads the cards and stores the data on disks (these predominate over magnetic tapes in NUMAC) from which files can subsequently be read and processed.

The Programs

The file is the unit handled by the LFP System. A file may contain bibliographic or other types of data. Stored in a "library" on a magnetic disk are programs which perform simple operations upon files and have as their result, or product, other files. The more important operations of which the LFP System is capable are as follows:

(i) Conversion of a file of bibliographic data from its form on punched cards to the internal form used on magnetic disks (or tapes). The program

does a certain amount of format checking, but it cannot spot errors of information content such as spelling mistakes and inconsistency among records in ways of writing the data.

(ii) Updating a file. The contents of one file are used to modify the contents of another. We can add records and remove them and can change records in any way.

(iii) Reproduction of files. Files can be copied in their entirety or we can copy records selectively (i.e. extract a sub-file).

(iv) Sorting a file. The records in a file are put into an alphabetical or numerical sequence (e.g. by item number, author, title or class number).

(v) Merging files. Two files, both previously sorted into one particular order, can be combined (merged) into a single file.

(vi) Printing files. Files, or selected records from files, can be printed in a wide variety of formats. The user of the LFP System controls the format of a printout (to a fine degree) by means of directives prepared on punched cards.

The structure of the LFP System is modular. That is to say that the programs comprising the system are mutually independent (though compatible) and any of them can be changed without affecting the others (by a programmer, maintaining certain file storage and other conventions). It is also not difficult to incorporate new facilities. The System contains no programs for accounting and is therefore not equipped to include a full ordering and accessions system, although the printing and file amendment aspects of the process can be done. Nor has it been designed to handle a circulation system, since the particular collection for which it was intended requires only a simple single-access loan record.

Use of the Programs

LFP System programs should be regarded as building blocks for constructing more complex processes. An operation which is complete from the library's point of view will normally consist of more than one of the processes mentioned above. For example, the production of an author catalogue at a time when the only file that is up to date is in item number order will require first a sort and then a printout. Any number of basic processes can be combined to form a single composite one and the user expresses his requirements in a simple command language. He writes, and then punches onto cards, a series of commands

which invoke the programs one after the other and specify which files are to be involved in the task.

When the library has experience with the LFP System and has established its routine use of the system, certain standard card decks will be submitted to the computer with little preparation necessary and at regular intervals. Within the limitations of the LFP System, the library will still retain the facilities for experimentation with its use of the computer. There is sufficient generality in the system for it to be useful to libraries other than the one for which it was written. It is worth remarking that if two or more libraries use the same computer and file processing system, compatibility between their records will make projects such as the production of union catalogues relatively inexpensive extensions to the routine.

1.2 *THE LIBRARY FILE PROCESSING SYSTEM*

The central part of the LFP System is a library of programs on a disk volume. There are programs which create, maintain, sort and print files of bibliographic data, and do related tasks and there are other programs which are used by them. These programs have been written in PL/1 and they are already compiled. To use them, we write a simple program of commands, each of which invokes a program in the library. We can thus have any combination of tasks performed and involve any file in the process.

The other important part specifically written for the LFP System is a program called the Library File Program Generator, which reads a program of commands and generates firstly a PL/1 program to call upon the appropriate task programs and secondly some instructions for the linkage editor so that the programs can be assembled in such a way as to economize on the core storage required by the final program.

The remaining important programs used by the LFP System are the PL/1(F) Compiler and the Linkage Editor; both are parts of the IBM System/360 Operating System.

Files are created by the programs in formats which are peculiar to the LFP System. The operating system finds space on the disks for the files and keeps them or deletes them as requested by the user in the job control statements. Records are constructed, processed and examined by the programs in the LFP System Library.

A summary of a normal LFP System job follows. The asterisks mark those parts which the user must supply.

* (i) A program of commands. Each command specifies a process and the files to be involved in it.

(ii) The program is converted to a PL/1 program by the library file program generator.

(iii) The new PL/1 program is translated by the PL/1(F) Compiler.

(iv) Program and library components are combined by the Linkage Editor.

* (v) The final program is executed. The files mentioned in the commands must be defined for the operating system by associating them with data-sets or devices.

* (vi) Various types of data cards to be read by the program.

Most of the remaining chapters contain descriptions of LFP System programs which can be invoked by commands. Some remarks are necessary at this point concerning the organization of the descriptions. Each program (or command) description contains information under the headings Command, Function and Notes, Data Definition Cards, Computer Time and Completion Codes. We shall discuss each of these in turn.

1. Command

A prototype command is given and followed by an explanation of each part of the command. The user should model his command upon the prototype, copying the uppercase characters and the terminating semicolon exactly and substituting his own, appropriate, text for the symbolic names which are underlined in the prototype. The second word in the prototype command is the name of the program being invoked and the words to the right of it are called parameters. Some of the parameters represent names, for example file names, and these must obey the following rules.

(i) A name consists of from 1 to 7 characters.

(ii) The first character must be a letter, others may be letters or digits.

(iii) There must be no spaces within a name.

Example

The prototype command for the sorting function is

label SORT infile sortfile sequence ;

"label", "infile", "sortfile" and "sequence" are all symbolic names, and an actual command in a user's program might be

A SORT LBK LAU SEQ601 ;

A detailed account of the use of the command language is given in Chapter 7.

2. Function and Notes

Paragraphs under this heading describe the purpose of the command and the roles played by the files involved.

3. Data Definition Cards

A data definition card is a particular type of job control card (see Chapter 7 and ref.119). Under this heading appears a list of the files which need data definition cards and any information which is peculiar to the relevant command. The general rule is that each file referred to (including implicit references) in the program must be defined just once on data definition cards in the job.

4. Computer Time

A formula for calculating processor time (CPU time), based on the amount of data and estimated from experience at Durham, is given. This should be used to estimate the CPU time requirement for the final job step (the operating system will terminate the step after one minute of CPU time unless we have asked for more).

5. Completion Codes

The computer finishes each task with a code to indicate its outcome. The codes most frequently used are:

(i) 0. Normal execution.

(ii) 4. The user is warned that certain situations were encountered. The execution may have been unsuccessful.

(iii) 8. An error was detected. The task will not have been completed.

(iv) 12. As for 8, but more serious.

If the command has been given a label, i.e. a reference name, the completion code can be used to determine whether other commands in the same program are obeyed.

Figure 1.1 contains estimates of the computer resource requirements for processing files of different sizes. The first column gives the size of the file. It should be emphasized that the larger of the two files maintained at Durham University has not, so far, contained more than 3000 book

records. The table, therefore, consists mostly of theoretical estimates. The second column in figure 1.1 is the estimated storage requirement for the file. The computer time used by the 73 LFP System jobs run in the months December 1970 to August 1971 (inclusive) are summarized in figures 1.2, 1.3 and 1.4.

Number of book records*	Storage % of volume**	CPU time given in minutes,seconds				Working Storage for Sorting, % of volume**
		Copying	Updating	Printing	Sorting	
2,500	1.4	0:04	0:13	0:17	2:20	3.5
5,000	2.8	0:07	0:26	0:35	5:00	7
10,000	5.6	0:15	0:50	1:10	10:50	14
20,000	11.2	0:30	1:40	2:10	23:30	28
40,000	22.5	1:00	3:20	4:30	48:30	56
60,000	34	1:30	5:00	6:40	72:00	85

* The size of the records is assumed to be as for those of Durham University Library, i.e. on average 98 characters of textual information.

** Storage is expressed as a percentage of a 2314 disk volume, upon which there are 4000 tracks.

Figure 1.1 Table of requirements according to file size

	CPU Times (seconds)				Total (Chargeable) Time (seconds) for 4-step Job
	M-step Program Generator	C-step PL/1(F) Compiler	L-step Linkage Editor	G-step User's Program	
Mean	1.69	2.15	5.79	58.13	166.55
Standard Deviation	0.41	0.24	1.6	77.5	106.06
Totals (73 jobs)	123.4	157.12	422.31	4243.8 (≈71 minutes)	12158 (≈203 minutes)

Figure 1.2 Computer time statistics for LFP System jobs run between 3 December 1970 and 1 September 1971

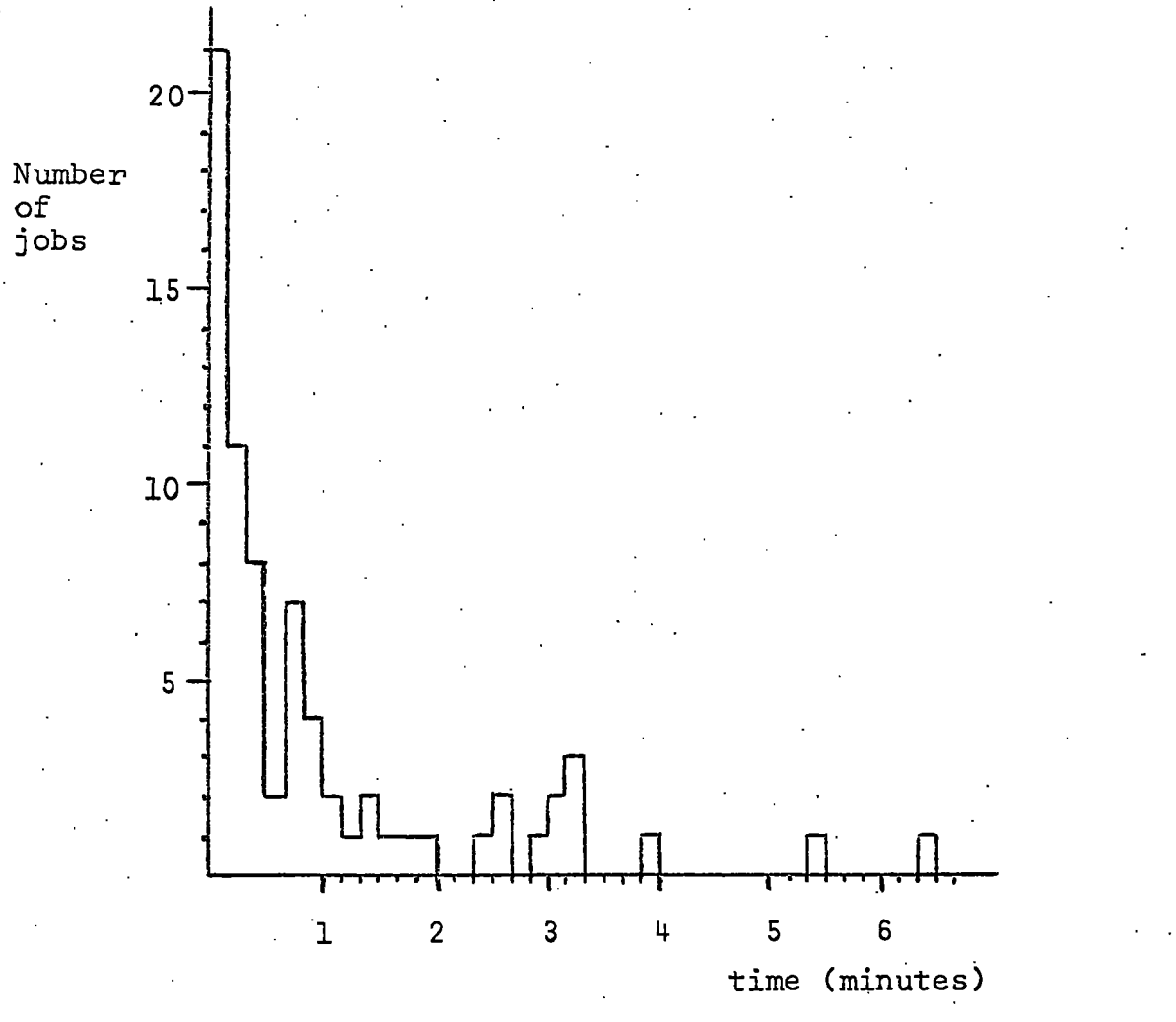

Figure 1.3 Distribution of jobs by G-step (user's program) CPU time (10 second intervals)

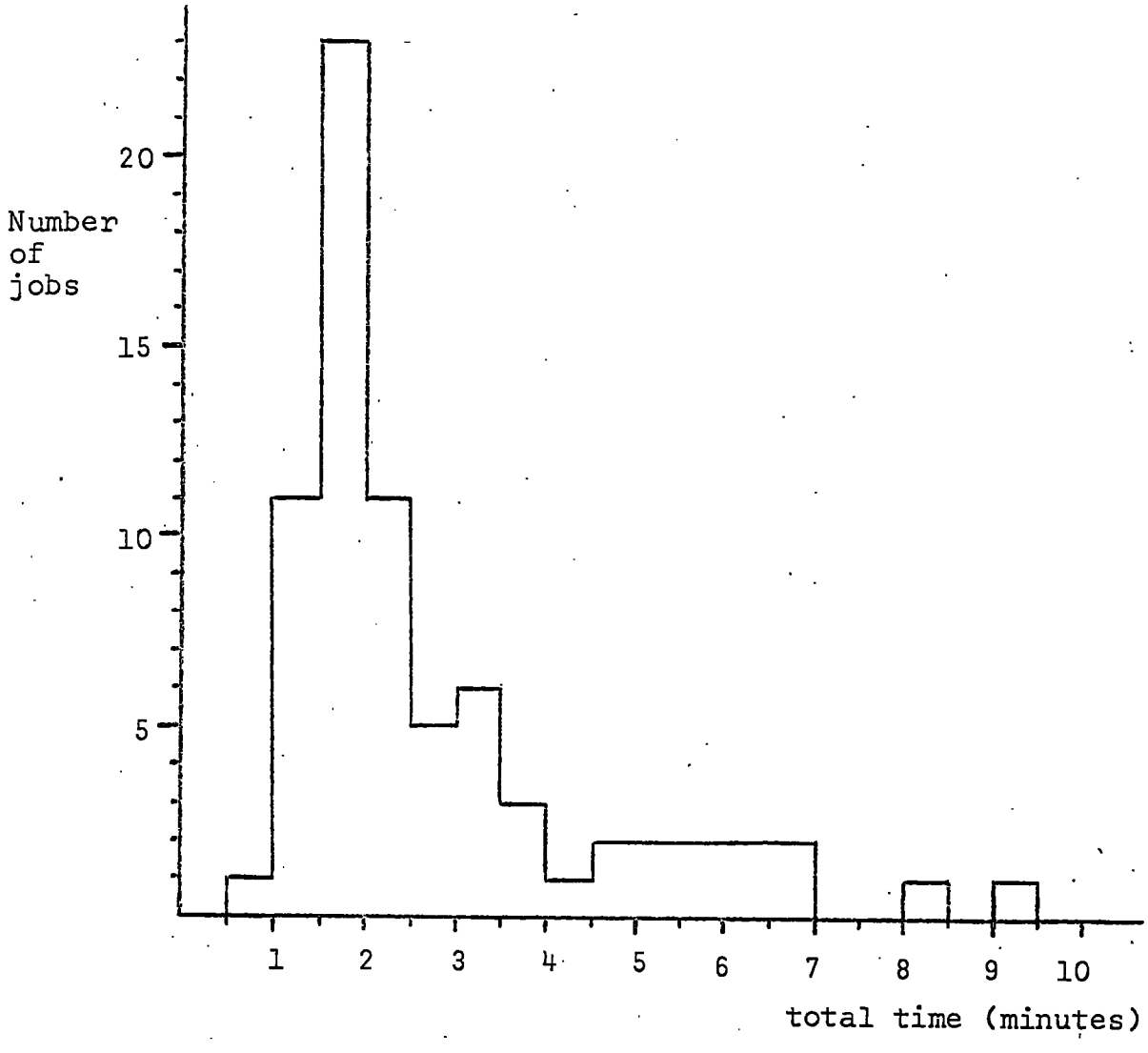

Figure 1.4 Distribution of jobs by total time (30 second intervals)

Chapter 2 discusses a few of the wider problems of catalogue making with a computer and may serve to put Durham's LFP System into perspective. Many of the problems in library automation arise because the files to be handled are both complex and very large and this project has not tackled them because its files are very small. What it has sought to achieve is to put versatility of computer usage into the hands of non-programmers in the library.

COMPUTER USAGE IN LIBRARIES

The processes applicable to the information stored in a library can be considered as having three facets. In order that it may be found again information entering the store must be organised. Interconnections must be established between items (a book must be placed in the correct shelf location, a catalogue card is filed according to definite rules), and hierarchical structures are maintained (there are books, catalogues and subject indexes for instance). Secondly, information must be transformed. Students and cataloguers, each in their own way, transform the contents of books; and filing entries in a catalogue requires what is equivalent to a non-trivial transformation of bibliographic details. Finally, information can be copied or moved. Books circulate among readers and records move to reflect their locations; contents of cataloguing slips or worksheets are copied to supply entries for shelflists and one or more catalogues. Clearly, there are no sharp dividing lines between these aspects of information handling, but they can serve to separate the clerical from the intellectual work. An important consideration is that enlightened analysis of a process can change one's view of what is intellectual by showing one a relatively straightforward clerical method of doing the same process. A library endeavours to organise its information in such a way that subsequent intellectual work in maintaining and accessing it is minimised. So far as possible, manipulation of established information should be a clerical job, one of copying and movement. Most of a library's professional staff are typically employed in acquisition and cataloguing departments. Computers are well adjusted to processes of movement and reproduction of information. At the machine level, for example, the IBM System/360 Universal Instruction Set has 143 instructions, 63 of which are concerned not with arithmetic or logic but simply with data movement. Basic modern software, the operating systems, upon which other programs build provide extensive storage management and data transfer facilities. It is natural, therefore, that computer techniques should have been investigated for use in handling the vast throughput of information in libraries.

Traditionally, and naturally, libraries organise their staffs into departments to deal with the following processes:

(i) Acquisition of stock, which involves selection and ordering,

(ii) Cataloguing, i.e. organising the material and supplying records to identify and describe it,

(iii) Circulation of stock among the readers,

(iv) Various services such as information retrieval and SDI (Selective Dissemination of Information), as appropriate and practicable,

(v) Maintenance of stock, e.g. binding and repair,

(vi) Management of resources, e.g. personnel, funds, buildings.

All of these require the creation and maintenance of files descriptive of the current state of affairs. We are concerned here with files directly related to the stock, the central one being the catalogue. Inevitably, there are close relationships between the members of a set of bibliographic files which relate to one collection, and the aim of library automation should be to exploit the relationships and enrich the set of files.

2.1 *THE "TOTAL SYSTEM" APPROACH*

A library organised as a single "total system" relies upon the ability to create a bibliographic record once and then use it, or a record automatically derived from it, to represent all movements of items in the library and to give appropriate bibliographic tools to the readers. In a recent survey of automation projects in British University libraries, Duchesne & Phillips[10] point out the growing interest in cataloguing problems and Parker[23] has remarked a similar trend in North America. The catalogue is central in a library system (not merely for access to existing stock) and its importance increases in a total system. Major progress in the automation of library functions depends upon mastery of computer methods of handling the catalogue. Thomas & East[27] studied the bibliographic records used in 12 assorted libraries and suggest optimal records for each of the 18 activities into which they divided the library function. The record produced by the cataloguing department is by far the fullest*; the table in figure 2.1 summarises the charts given in [27], p.45-50. The catalogue record having been produced, all the other records can be regarded in retrospect as extended subsets of it; and most of them of temporary utility. Many of the impermanent fields are dates copied from a calendar (or date-stamp) and the others are equally amenable to automatic assignment.

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* Thomas & East do not attempt to summarise the catalogue records of the 12 libraries and one cannot, from their publication, relate the records to the size or type of library. The libraries fall into two distinct groups as regards the size of their catalogue records; seven use from 13 to 16 fields and the other five libraries use 23, 24 or 25 fields.

Field name	Number of libraries (out of 12) using field in cataloguing
Author	12
Additional authors	12
Editor	12
Compiler/Translator	10
Title	12
Sub-title	11
Edition	12
Volume	12
Series note	11
Publisher	11
Date	12
Place	11
Price	4
No. of copies	6
SBN	3
Date of invoice	1
Library	6
Bibliography	5
Diagrams	5
Illustrations	5
Pagination	6
Plates	2
Tables	4
Graphs	2
Size	3
Abstract	7
Class	12
Accession no.	8
Subject descriptors	3
National Bibliography no.	1

Figure 2.1 Summary of the catalogue records of 12 libraries, derived from charts given by Thomas & East[27]

For some time, librarians have been concerned that the hard work done by the acquisition department in identifying and describing literature should be utilised to the full by the cataloguer [9,24,104]. An additional major consideration is that among the libraries of similar organisations (e.g. among university libraries) there is a considerable overlap of stock, all catalogued independently. There are justifiable differences between libraries and consequent differences in their catalogue records (there are also traditions!) and standardisation is difficult. The Library of Congress and the BNB MARC (MAchine Readable Cataloguing) projects are a significant attempt to provide libraries with comprehensive bibliographic records for monographs prepared centrally and suitable for automatic modification to suit the many requirements of a large range of libraries. The timely availability of MARC records and the technical means for their manipulation places the library, in theory, in the strong position of being able to generate automatically all its records by simple extension of various subsets of MARC records.

The Library of Congress started distributing magnetic tapes to 16 selected libraries in November 1966 as part of the MARC Pilot Project, and the record format used then is described in the Final Report[34]. In 1967, the Library of Congress reconsidered the design of the bibliographic records and the British National Bibliography co-operated in the formulation of MARC II, a considerably more versatile format which brought into the foreground the concept of a communications format from which could be derived records for a wide variety of purposes. Not only is the record a very full bibliographic description, but it also has a detailed structure which conveys information about the semantic content of the fields. A complete description of the MARC II format would be very long (see refs. 36,43,47 for details), so we give here a summary - figure 2.2 - and a brief indication of the tag structure.

Each field of bibliographic data is tagged by a 3-digit number. The first digit defines the function of the field; for example, '1' is Main Entry, '2' Title, '6' Subject Added Entry. The other two digits describe the kind of heading and, where appropriate, there is some consistency; for example, in the Main Entry (first digit '1'), Series Notes ('4') and various added entries ('6','7' and '8'), a value of '0' for the second digit means "Personal Name" and '1' means "Corporate Name". Data is prefixed by two indicator characters which further describe the type and whose significance varies from tag to tag, and the fields are segmented into subfields composed of the logical parts of the data. An example will probably convey the essence of the scheme without the need for details:

tag '100' , Main Entry , Personal Name

variable field

'10$aBEECHAM, $eSir $hThomas, $dbart£

Indicators — Subfield codes — Field terminator

leader	directory	variable control number	variable fixed field	variable fields . . .	#
24					1

leader:

record length	record status	legend	indicator count		base address of data	
5	1	5	1	1	5	6

record status defines whether record is new, changed, deleted or old.

legend describes the type of library material referred to.

indicator count is the number of indicator characters in the variable fields ('2' is used at present).

base address of data is the total length of leader and directory.

directory:

directory entry	directory entry	. . .	£
12	12		1

directory entry:

tag	field length	position
3	4	5

tag is a 3-digit number identifying the type of field.

field length is the number of characters in the data field.

position is the character position of the start of the data field relative to the start of the variable control number field.

£ is the field terminator.

variable control number (tag '001' in the first directory entry) is the LC card number of Library of Congress records or SBN or BNB serial number in BNB produced records.

variable fixed field (tag '008' in the directory) is a single string of codes and dates of fixed length for monographs, but which will need to be different for other types of material.

variable fields, each described by one directory entry with an appropriate tag, consist of two indicator characters (see leader) followed by data (which may be divided into subfields by special codes) followed by the field terminator.

is the record terminator.

Figure 2.2 MARC II Format summary

The chart in figure 2.3 illustrates how bibliographic records could move in a library system. In the chart, processes are simplified and some important sub-systems are omitted altogether (e.g. serials accessioning and holdings list maintenance). What prevents the "total system" from becoming a reality is the considerable difficulty encountered at two points: the entry of selected MARC records and manipulation of the Catalogue file (we are not yet considering the "one-off" task of bringing a large established catalogue into line with the new automated system). Selection of library material requires access to information concerning new books, if not before publication then very soon afterwards. It also needs efficient access to the "retrospective file", i.e. records of all past publications. MARC has received criticism on its timeliness; a conclusion from a survey done by the Birmingham Libraries' Co-operative Mechanisation Project is "that MARC records need to appear very much more promptly if they are to be of maximum use for cataloguing. Timing is less critical for cataloguing than for selection and ordering: even greater improvement is required if MARC is to achieve maximum usefulness in the latter fields."[45] MARC tapes must have maximum usefulness in selection and ordering in order to have maximum utility in the library as a whole. Also, in a very few years, searching for post-1968 English language books on MARC tapes will be technologically equivalent to searching the catalogue of a very large library using a computer. Eliminating the records for purchased items from the cumulated MARC file will reduce its size and Ayres[37] has suggested the maintenance of a "Potential Requirements" file created by blanket-selection by subject from the distributed MARC tapes. Even so, the average provincial university library will need to keep quite a large MARC file because its potential requirements are high and its budget is low. Local preparation of machine readable records by locating and editing entries in such bibliographies as BNB will probably be more economical than the use of MARC for most libraries for some time to come, and this approach may well be encouraged by the introduction by BNB itself of the microform bibliography "Books in English"[39,60]*. However, for efficient record handling in the library as a whole, centralised cataloguing and distribution of machine readable records with the computer technology to process them in bulk is necessary so

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* Two month cumulations of British and American MARC tapes are merged into Dewey Classified sequence and formatted for output on microfilm. NCR reduces the microfilm image and produces 4 x 6 in. microforms, each containing up to 3000 pages (about 48,000 entries). The microforms are tough and cheaply produced from the negatives. They are viewed on a manually controlled reader either by using the classified index to the co-ordinate system given on the microforms, or by "flicking through" them like and, with practice, as easily as books. This medium seems to have considerable potential in many areas of library work.

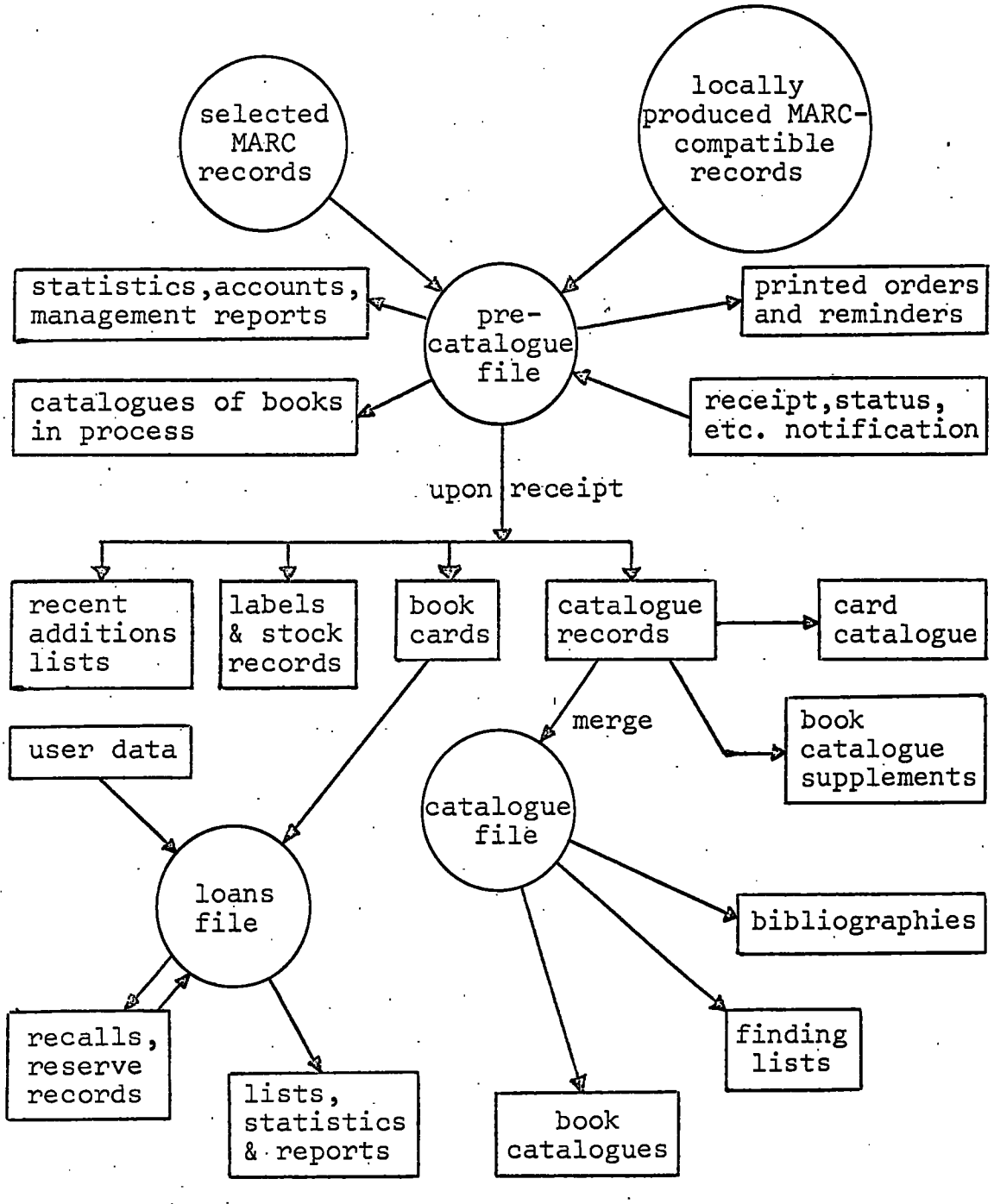


Figure 2.3 Movement of bibliographic records in a library

that full bibliographic details can enter the system at the earliest possible stage. Grose & Jones[101] and Line[104], describing the first operational, computer-based order system in a British university library, pointed out that the information in the order file on magnetic tape should ideally be passed on to the catalogue. However, rather than expanding and editing an order record to form a catalogue record, it would be better to take part of a catalogue record for the ordering process.

When a library wishes to introduce the use of a computer into its procedures, it will very likely have to restrict itself to a sub-system which must be kept in continuous operation, and the automation of which must not be allowed to interfere with the operation of other, conventional (and working) sub-systems. The result is that most automation schemes in libraries mimic conventional operation. On the whole, libraries are pleased with their automated systems mainly because they can provide a better service through the greater accessibility of information. Few libraries, however, can report a substantial reduction in costs over the old systems and, perhaps, this cannot come until records can be moved speedily and automatically between any two points of a total library system. The logical conclusion of this line of argument, as expounded mainly by American authors, is that a library should maintain one all-embracing bibliographic file from which all products are generated, all queries answered and all processes controlled. "It is more economical to handle a variety of library applications by using a single file and a standard set of functional programs, than it is to provide a separate file and a separate set of application programs for each application. Not only is it more economical, but this total integrated approach is, in its essential modularity, extremely flexible." - Warheit[29]. This attractive picture is, at the present time, futuristic; currently available techniques cannot achieve it economically, if at all. Whatever technique is used, from manual to on-line computer, one does not want a file of a million large and complicated records constantly at one's elbow, for even the simplest task. Warheit's words were written in the context of a discussion of interactive computer systems, and these probably offer the only possible environment for this form of file-driven system. In the meantime, much can be done to improve the readers' and librarians' access to the bibliographic files in the library and we now concentrate on the role of computers in producing catalogues, bibliographies and other lists.

2.2 *CATALOGUE PRODUCTION*

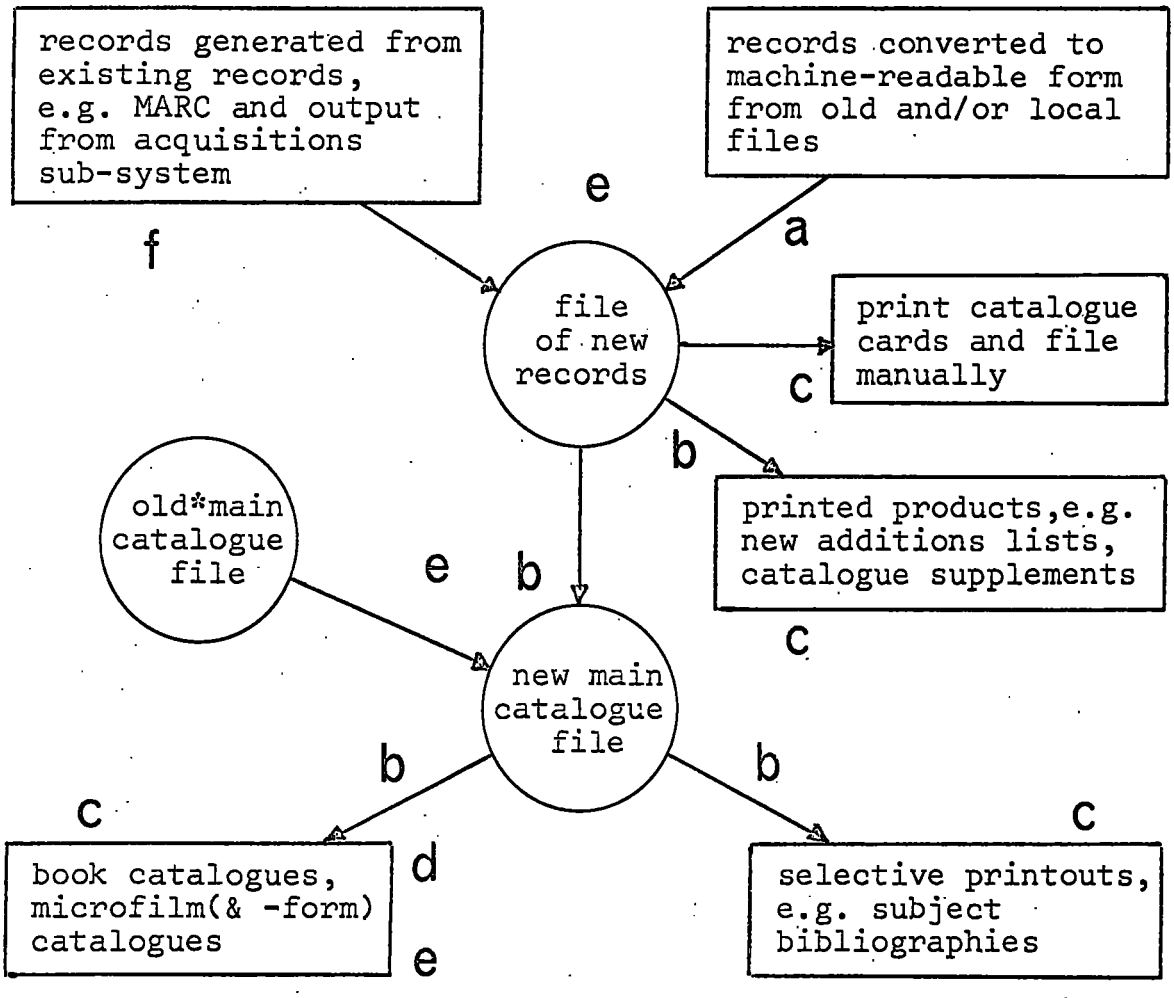
Predominantly, computers have been used in libraries as sophisticated, high speed, giant typewriters. They are provided with "machine-readable" records which they are programmed to shunt from store to store, reformat for more

convenient handling in particular circumstances and prepare for output in various arrangements, to suit the intended user. Figure 2.4 is an overview of those parts of the cataloguing function which can be done on a computer; rather than representing a single library's system, it is an amalgamation of the main facets of several working systems and experiments. The chart includes an "index to problems" and we discuss some aspects of those problems.

1. Conversion of Old Records

Opposing the acknowledgment of the centrality of the catalogue in library automation policy-making is the substantial cost of converting to machine-readable form the million or so catalogue records in the typical well-established large library. French[60] has estimated the costs of various possible conversion operations on Birmingham University Library's catalogue and found the cost of keypunching to be about £60,000. If it is thought desirable (or necessary) to bring the old entries (at Birmingham) into compatibility with current cataloguing practice the cost nearly doubles. A new format has sometimes been required for preservation of the catalogue or because a fast growing catalogue was becoming more and more difficult to manage and use in its existing form. In that case photographic techniques can be used (at a tenth of the cost of keypunching) to produce book catalogues. The versatility that computer-handling of the records can give is missing from these methods but, as French points out, a cheap, temporary solution may be what is required since the large national libraries here and in America are investigating the problem of converting their catalogues to MARC form and most of the local library's catalogue will be covered. The selection of records from such enormous central files for each library will certainly pose considerable technical problems and some libraries will not wish to wait.

At present, five types of hardware can be considered for initial preparation of catalogue data in machine-readable form, and they all involve typing. The well-established methods are the paper tape typewriter and the 80-column card keypunch. The former has been favoured by library automation teams [23,61,34] because of the ease with which a larger character set can be handled and in order to avoid the fixed-field aura of punched cards. The first reason is valid; coding more than the usual character set comprising upper case letters, digits and mathematically oriented special symbols normally requires on the card punch the reservation of graphic characters for case shifts, and representation of non-spacing characters is awkward. Most people who have used punched cards for input have divided their cards into fields, but this is not necessary; programs can be written to regard a deck of cards as a continuous stream, like paper tape (see Chapter 3), and cards are more easily edited than tape.



*old & new main catalogues may coincide on direct access storage

Index to problems:

a	Input: retrospective conversion of old catalogue
b	Filing for merging and rearranging files
c	Quality of output
d	Maintaining currency of large public catalogue
e	Growth: doubling time is 10-20 years
f	Availability of full records (see section 2.1)

Figure 2.4 Automated catalogue maintenance: overview and problems

A development from punching devices is the magnetic tape encoder. Keyboards for these devices vary from the simple keypunch style to the large and versatile one of the Keymatic which the Library of Congress RECON Pilot Project group found attractive[55]. In the normal commercial environment editing is simple and efficient with magnetic tape encoders, but this may not be so in the library where the record is so much more complicated.

The fourth method of input is the use of OCR (Optical Character Recognition) equipment. The present state of the art requires that data be typed using one of a number of founts designed for use with a page reader. Character sets are severely limited except on the most expensive models. The RECON Pilot Project started in mid-1969 at the Library of Congress with the plan to experimentally convert 85,000 recent English language and 5000 old and more varied Roman alphabet catalogue entries to MARC format (a series of reports in the Journal of Library Automation maps their progress; refs. 54, 55,56). Avram[54] evaluates OCR for use in this context and concludes that "Paper handling is a major drawback of optical character readers . . . Typewriters used to prepare the source document must be constantly cleaned and ribbons changed to keep impact keys free of dirt. Frequent jamming appears to be a characteristic of most machines". In spite of that, a later report[55] describes a system of input using the services of a bureau to prepare data and copy it to magnetic tape with an optical page reader. Brown[59] reports a similar method at the Bodleian Library in the conversion of the pre-1920 catalogue. The use of a bureau makes the more sophisticated optical readers an economic proposition in competition with the older methods for operations of this type. Reading the original catalogue cards is evidently not yet within the capability of marketable machinery.

The final general technique for input of catalogue records is on-line to a computer; the typist uses a console which is under the (effectively) continuous control of a program. Balfour[57] has described the conversion of a shelf list of about 100,000 records using IBM 2741 typewriter terminals under the control of DATATEXT, the forerunner of IBM's Administrative Terminal System, ATS[66,67]. Editing facilities are impressive but, it could be argued, too general for use in a single large application where a tailor-made conversational program might pay in the long run, even with programming costs. According to Dolby et al.[86] on-line input of catalogue data is more than twice as expensive as the other four methods considered above, which are indistinguishable as regards cost. Whatever method is used, good file-editing software will save expensive manual correction procedures[112].

A major and obvious way to make economies in data preparation is to minimise key-strokes, and two aspects of bibliographic data make this very much a non-trivial matter. Firstly, the

number of characters to be represented is far greater than the number of keys on any sensible sized typewriter and therefore extra key-strokes are required to denote case or mode. The representation of characters on the input device is almost solely a matter of ergonomics and can be independent of the stored representation which is designed for storage economy, ease of scanning, filing, etc. Price[71] gives a useful exposition of character set design in general, and the Newcastle University Catalogue Computerisation Project gave special attention to the subject as it applies to typing paper tape, building into the project measures of typist performance and the efficiency of the character representation[73,74].

Secondly, variety in record manipulation and output is dependent upon the input record being divided into well defined fields (the MARC II format is perhaps the extreme illustration of this) and in a simple-minded approach to preparing the record for automatic handling identification of the fields can increase the number of key-strokes significantly. The input procedure for the Durham Short Loan Collections requires five control characters for each field. A great deal of effort has been devoted to devising algorithms which analyse a catalogue record with a minimum number of one-character field delimiters and build up a full structured record, assigning tags or otherwise identifying the separate fields. The RECON Pilot Project [56,69] has simulated its automatic format recognition manually on a few hundred catalogue cards and achieved about 70% accuracy in MARC II format tagging. They are in a fortunate position both in that uniformity in the cataloguing is quite good, and in having a sizeable file of MARC records with which to experiment. MARC records can be used to generate, automatically, test files of unstructured catalogue entries of high quality, and the output of the formatting algorithm can be assessed quickly and reliably by comparison with the original MARC tapes. Jolliffe, describing in some detail an experiment on the British Museum General Catalogue of Printed Books[68], summarises this type of algorithm as follows: "The program, essentially, represents the interconnected web of alternatives at different points in a BM catalogue entry". His internal code allows for a representation of typography, which varies systematically within entries and can therefore be used in the programmed analysis. Estimates of the accuracy of tagging (or equivalent identification) in two other British projects are 94% of fields at Newcastle University (details of the method are given in ref. 74) and 97% of fields (90% of entries) for the pre-1920 catalogue in the Bodleian[59]. These figures show that the techniques for format recognition in catalogue entries are sufficiently developed already to be very effective cost reducers and that when optical machine-reading of existing printed (or hand-written) catalogue records is feasible, the software will be ready to structure it. An implication of the growth of published information is that the techniques which are now required for retrospective conversion of huge catalogues will one day be needed for encoding new records.

2. Filing Catalogue Entries

Contrary to the usual connotation of the word, filing in the context of a library catalogue is far from being purely clerical, and to implement in a computer sort the rules as they stand in a typical library is well outside the scope of existing techniques for handling linguistic data. A brief excursion into the ALA Rules for Filing Catalog Cards[80] will illustrate the situation. On page 1 we find the Basic Principle:

> "Filing should be straightforward, item by item through the entry, not disregarding or transposing any of the elements, nor mentally inserting designations. In the following rules there are only a few situations where this principle is not applied; these are usually due to the structure of the heading."

The rules are written for the human filer, whose idea of what is straightforward is the result of his experience and the meaning which he attaches to the headings. An exception to the Basic Principle which can be handled reasonably well by a program is (Rule 4A) that initial articles in all languages should be ignored. The exceptions to this are foreign articles which are compounded or of case other than nominative, i.e. words like the French du and des and the German dem and den are regarded (and presumably German der is disregarded when it is nominative, masculine but not when it is genitive, feminine). There is still an exception: the Dutch 's, which is a contraction of the genitive des, is disregarded when it occurs as an initial article. Other rules pose even greater problems for the writer of an automatic filing algorithm. The treatment of numerals (Rules 9A-9D) and variant forms of headings (Rules 10-12), and classificatory filing (Rules 26-28) all require semantic analysis which only human brains can do at the present time. Nevertheless, a computer-based cataloguing system would be very restricted without the ability to sort, so various approaches have arisen to enable items to be filed automatically in a way that resembles the customary way. It is also worth noting that if the catalogue entries can be scanned easily (e.g. in the book form as opposed to cards), the effect on the searcher of slight differences in filing order is reduced.

Broadly speaking, the approaches to this problem fall into two classes. The first involves the preparation of additional data or bending of cataloguing rules to aid in (or avoid) the solution of the computing problem. The other is to do one's best with the conventional headings, as they stand. From the programming point of view, the simplest approach is to assign numbers to all the entries so that sorting the file into ascending numerical order puts it in the required sequence for, say, an author catalogue[76]. The filing is really still done by the librarian when he assigns the sequence number. In byte oriented computers one is usually able to compare two character strings, even of different lengths, with very short instruction

sequences, and using one or more of the fields in the record, unmodified or translated byte for byte to get the required character collating sequence, the production of a sort key is simple. To use such simple techniques, the cataloguer must, in effect, provide the sort key, either in addition to other, standard, headings or instead of them. With extra, quite straightforward programming one can provide for both conventional heading and conventional filing without supplying both heading and sort key except where they differ. Special symbols are introduced into the fields to indicate that some characters are to be used for filing but are not to be printed and others are to appear on printouts but must be ignored when the sort key is constructed. Characters which fall outside the scope of the special symbols are required both for filing and in the printout[88,20]. An example given by Johnson[88] is as follows. To obtain the normal chronological order of these subject headings:

ROME-HISTORY-REPUBLIC, 510-30 B.C.
ROME-HISTORY-REPUBLIC, 365-30 B.C.
ROME-HISTORY-AUGUSTUS, 30 B.C.-14 A.D.

the following fields are entered:

ROME-HISTORY-<REPUBLIC, 510-30 B.C.>@Z9489-Z9969@
ROME-HISTORY-<REPUBLIC, 365-30 B.C.>@Z9734-Z9969@
ROME-HISTORY-<AUGUSTUS, 30 B.C.-14 A.D.>@Z9969-0014@

Characters enclosed in < and > do not take part in filing and those within a pair of @'s are never printed. The sort keys used are:

ROME-HISTORY-Z9489-Z9969
ROME-HISTORY-Z9734-Z9969
ROME-HISTORY-Z9969-0014

Most headings will not require the use of "file as if" statements but the extra effort required to produce them is nevertheless significant. Hines & Harris[78] set out a code which allows characters to be disregarded but does not use additional non-printing strings. Their approach is to put "into writing the entry form which the filer is already required to visualise in order to place the entry and which the user must now have in mind in order to locate it." In addition, three special symbols are used; a space to be disregarded when filing, a space valued character which does not print and a character to enclose strings which do not participate in the filing.

It is not practicable to use the above methods of automatic filing either in a large "converted" catalogue or in files of MARC records because library staff would have to perform a large editing operation. Methods are therefore developed to generate automatically, from existing fields, sort keys which give an acceptable filing order. Probably the most important single

operation in creating the sort key is to remove the leading article if there is one. Bregzis, for example, describes a program which can remove the articles of 27 languages by searching whichever vocabulary of articles is determined by the language code in the record[75]. He also expresses the view that the programming and operational costs of implementing very complex filing rules is not justified because the public would probably find simple rules no less convenient. Coward[43] and Davison[77] both point out the way in which the tags, indicators and subfield codes of the MARC II format aid filing by providing programs with the means of distinguishing between different types of entry and of separating out components of names (in addition the second indicator in some of the title fields is the number of characters at the beginning of the title to be ignored when filing).

3. Book Catalogues

At the turn of the century, catalogues of libraries' collections were normally kept in book form, several entries per page, bound conventionally in large volumes. As collections grew, the difficulty of maintenance of this form gave rise to card and sheaf catalogues* in which each entry has a "page" to itself (usually measuring 3 x 5 inches). The card catalogue is stored in an array of drawers, about 500 cards (entries) per drawer. The drawers are not filled to capacity so that insertions can be made without causing a ripple of overflows from drawer to drawer through the catalogue. As the catalogue grows, periodic reorganisation is needed, but new items can be filed daily and the catalogue is therefore always up-to-date. A sheaf catalogue is similar to one in card form in many respects. Entries are on paper rather than card and are secured, again in sub-capacity sheafs of 500's or so, in binders which have large labels on their spines. The binding is particularly secure and it is not a quick operation to file a new entry. Filing in the main catalogue is therefore done periodically (e.g. termly or semi-annually) as a major job. Now libraries are considering the book form of catalogue again in view of the fact that computer methods and printing machinery go a long way towards solving the updating problem and because new catalogues are needed to replace old, deteriorating ones and to provide better access to the ever-increasing volume of literature. Figure 2.5 summarises the relative merits of these three types of catalogue.

The cost of producing a book catalogue for a large library is high even with the aid of a computer and much has been written, especially in the United States, on costs and strategies for reducing them[86,87,64]. One of the major advantages of book catalogues is that they can be "mass-produced"; that they

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* Catalogue "conversion" has been done before.

	Performance Factors	Form of Catalogue: Card	Sheaf	Book
MAINTENANCE	Updating	Easy	Awkward	Difficult, but computer can help a lot
	Space requirement	Very large	Large	Quite small
	Preservation	Difficult, and risk of destruction is serious		Ease of printing multiple copies removes problems
USE	Location of known headings	Initial, search-narrowing, phases fast		Fast, if page headings are good, but can be hindered by having to use supplements for new entries
	Scanning	Tedious	Quite easy if user is right-handed	Easy
	"Multiaccess" (simultaneous use by several people)	Fair	Quite good	Depends on number of volumes and number of copies
	"Remote access"	Poor; often none at all		Possible at a reasonable price

Figure 2.5 Comparative performance of card, sheaf and book form catalogues

must be periodically completely reprinted to incorporate new entries is probably the major disadvantage. There are various ways of obtaining multiple copies of computer output - photography of line printer output to produce offset masters[88], printing directly onto continuous Multilith stationery[93], production of tapes to control a typesetting machine[85], computer output on microfilm which can then be used for printing[90]. As the cost of using the newer equipment comes down (through bureaux, for instance), it is becoming quite feasible for a library to produce a high quality document and, as Dolby et al.[86] point out, the higher density of characters on the page which is possible with typesetting methods makes for shorter, and therefore cheaper, catalogues (they are also easier to read, scan and physically handle).

Updating book catalogues is usually done by means of the issue of supplements in conjunction with, typically, an annual reprinting of the entire catalogue. So that the catalogue user does not have to look in too many places, the supplements are often cumulated; for example, the Meyer undergraduate library at Stanford started by printing the catalogue annually and issuing quarterly supplements, each of which incorporated the previous one[88]. Another approach, which does not seem to have received much attention, is to mimic the technique used in the original looseleaf shelflist at the Widener Library - the large sheets originally had plenty of space for additions. The computer equivalent might be a file in which page boundaries and numbers are recorded with the bibliographic records. A certain amount of free space should be reserved initially in the "pages", the amount to be determined automatically for each part of the file, depending upon previous updating patterns (this quantity might average about 6% over the whole file; it would be directly related to growth rate). The printed book catalogue would be looseleaf and would be updated by periodically replacing pages where additions had been made (overflow pages would also be necessary in places). Every few years (5 say), the file should be "smoothed out", pages renumbered and boundaries realigned. The saving in this method is that relatively few pages need printing in order to obtain an up-to-date single sequence. On the other hand, one has the cost of manually changing pages in all copies of the catalogue. The effectiveness of the method depends on the pattern, or distribution, of updating. In the old Widener shelflist it was regarded as unfortunate that the additions came in unevenly over the years[70]. A computer equivalent might not be worth having if the distribution were not very uneven. For this reason a subject catalogue would be cheaper to maintain than a name catalogue in which one would expect an alphabetic distribution of new entries just like that of the existing ones.

This chapter concludes with some remarks about the contents of the entries in bibliographic lists and catalogues. The question "What should a catalogue record contain?" has been discussed for a very long time but the discussion has been

rejuvenated by the emergence of the computer as a viable tool for library operations. Maintaining a catalogue is so expensive that the number of different catalogues that can be kept is severely limited. Nearly all libraries have an author (or name) catalogue and a shelflist, often a by-product of cataloguing, and some keep a separate subject catalogue (others direct their readers to the shelflist!). The computer, regarded and programmed as a symbol manipulator, operating on a structured record offers a wide variety of bibliographic tools for both librarian and reader. The cost of producing a book catalogue with traditional entries, even using a computer, is still high and one needs funds in order to exploit the versatility of the computer. A promising proposal is that a library should produce various lists of brief entries at much reduced costs and include a precise reference (probably numerical) to a full master record elsewhere. The assumption is that about 90% of catalogue use can be achieved on a much simpler record, and probably achieved faster. Suggestions as to what the detailed back-up file should be vary from the accession register[95] to an on-line catalogue[24], while Line[50] suggests the use of national bibliographies, in which case one doesn't need a full local record at all.

Among many other fascinating calculations, Dolby et al[86] present an argument which shows that the saving to an institution in reducing the time per catalogue-usage by one minute is comparable to the library's cataloguing budget itself. Moreover, that minute is actually recoverable by putting a copy of the catalogue in the user's department. The possibilities with PCMI transparencies in this field are exciting; the ratio of catalogues to staff library users could be very high (one?). The viewer costs about £300 and the microforms can be produced from a negative for a few new pence. A short-title catalogue of 500,000 entries, formatted at 30 to the page would require 6 microforms.

A catalogue is a list of books, etc. and there should be a unique mapping from the list onto the collection, though not necessarily vice versa. In a shelflist, one requires a one-to-one mapping but in an author or subject catalogue, many-to-one is generally regarded as positively advantageous. There must be fields of information in the catalogue record which unambiguously identify it as corresponding with a particular item in the stock. A record contains fields of two general types[86]*. Item fields are those which correspond uniquely (or nearly so) with items of stock; author, title, accession number are considered to be item fields. All others are called class fields because one expects to find classes or groups of items with the same value for a field of this type. The choice

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* Dolby et al. make this distinction for a different purpose, that of determining the theoretical number of useful orderings of a file.

of which fields to use for identification of an item should coincide with the fields used by readers when they refer to the literature, i.e. normally author first and then title. This choice is probably determined by existing bibliographic tools, arranged in author order, and is not necessarily the best. Ayres[81], for example, argues in favour of title catalogues on the grounds that a survey in a special library demonstrated that people give more accurate title information than they give authors. Authors and titles are generally thought of as item fields, but are not really very good ones (authors tend to write more than one book). True item fields are always "artificial", that is they are assigned to the item by "turning the handle". Examples are the accession number generated locally and the SBN (assuming that one does not wish to distinguish between copies). The user identifies items by his search terms, so catalogue records must be organised according to those terms and the artificial fields cannot be used. Library users will never be expected to locate by accession number but the question "Have you got ISBN 0 85362 105 5?" might conceivably, one day, be in the preferred form. In the meantime the field requirements vary from list to list. The Short Loan Collection in Durham University Library's Science Section is so small that satisfactory access by author can be obtained from a listing of authors' surnames and the works' titles. That would not do for larger collections (the larger the catalogue the more fields are required, with diminishing returns) or for special bibliographies. Readers would not use the author field at all, for instance, in searching a bibliography of editions of writings by Shakespeare.

3 *BIBLIOGRAPHIC FILES*

In this chapter, we do some of the groundwork on files with specific reference to the Library File Processing System. Firstly, some basic words are defined and the structure of files is described in general terms. Then the forms in which the files are stored and the methods employed by the computer programs to process them are discussed, again in quite general terms. Finally we get down to details of the preparation of files for the computer.

3.1 *FILE STRUCTURE*

File. We define a File as a collection of records in some sequence. The records can be in some sort of numerical or alphabetic order or just in the order they were thought of. The order is mentioned simply to emphasize the sequential nature of the file processing done by this system.

Record. The Record is the conceptual unit of information in the file. When we are thinking of the file as a file of bibliographic information, the record is the aggregate of information pertaining to one book (or to whatever the bibliographic unit is).

Item. An Item is a record in this particular context. That is, an item is a bibliographic record. Thus, when the word record is used, we will usually be thinking about the file from some other point of view. For example, if the file is punched into 80-column cards, we might use the word record to mean all the characters on one card, even though an item spans several cards.

Element. The item can contain several different types of information. For example, most items will contain the name of an author and a title. These sub-units within an item are called Elements (or sometimes Fields, although that word is used slightly differently in connection with the printing of lists). In this system, there is a limit to the number of elements an item may have and there are certain size restrictions, which vary from element to element. The semantic significance of the different elements is largely at the discretion of the user of the system. An item need not contain an element from every possible category.

Tag. The elements within an item must be identified. There are two methods. The first is to identify it by its position in the record as, for example, on a catalogue card. The other method is to attach a label to each

element saying what sort of information it is. These labels are called Tags or Element Identifiers. The LFP System uses both methods at various times. When tags are used, they are numeric.

3.2 *FILE REPRESENTATION AND STORAGE*

Before files of bibliographic data can exist within the computer they must pass through two intermediate forms in the LFP System. The first of these is a bundle of slips of paper written by a librarian. The other is a deck of 80-column cards key-punched by the data preparation service directly from the slips. These, of course, are readable by the computer and are normally reformatted for reasons of efficiency before being stored on a magnetic recording medium such as a disk or a tape.

General comments will be made at this stage about the different forms of file. Details of the first and second representations are given later in this chapter.

Files on Paper Forms

Forms are printed with blank areas for all the elements which might be required in the items. Clearly, it is convenient if one form contains one item, but it would have to be a very large form indeed to allow for every possibility. One can design quite a small form which is of adequate capacity for the large majority of items and which can also be used as a continuation form for the remaining large or awkward items. The forms used by Durham University Library have the numeric element tags printed on them for the benefit of the card punch operators as well as an element name (e.g. "author") for the use of the librarian who fills them in.

Items on Punched Cards - External Files

Items are punched directly from the forms prepared in the library. Each element is typed with the appropriate tag preceding it and a special terminating character following it. Another special character is used to separate the items in a file. The format is fairly free, that is items and elements can be arranged without regard to the exact position on the cards. We shall refer to a file of items organized in this way as an External File, or File in External Format, because it is in the form that is used outside the machine.

Files in Internal Format

External files are not organized for efficient processing - they are just readable. In the Internal Format, elements are identified by their position in the item. The format is described in [125],p7-14; it is slightly complicated to allow - without too much wastage - for the variability of some of the

field lengths and of the number of fields included in an item. Internal files are created and manipulated by the computer programs. They can be stored on disks, magnetic tapes or other high capacity storage devices, but not on punched cards unless they are first converted to the external format. In Durham University, the internal files are kept on disks.

Note on Card Files

A Card File is a file in which the information is divided into records of 80 characters, regardless of the nature of the information. Both of the following are card files:

A deck of punched 80-column cards
A file of 80-character records (Card Images) on a disk

Programs which read or punch real cards will also read or write card files on disk or magnetic tape. External files are card files (although not necessarily vice-versa) and can exist on disks and be read by programs from there. We use other card files in this system and they are described in later chapters.

3.3 *COMPUTER HANDLING OF FILES*

Firstly, all files are given names, which are chosen by the user.

Secondly, the bibliographic files are always handled Sequentially in the LFP System. That is to say that a file is a sequence of records and the programs which read them will "see" the records in the order in which they were written. Selection of items with certain characteristics from a file is done by reading the file from start to finish, testing each item and selecting or rejecting it on the result of the test. Sorting is the process of rearranging a file into some predefined sequence which may be different from the existing one.

We now discuss briefly the two basic file operations used by all the programs - reading files and writing files.

Input

This is the straightforward process of a program reading a file sequentially, starting at the first record. Note that if a deck of punched cards is specified as an input file, the program can read it only once during a job.

Output

The program writes, punches or prints a file. If the file is written onto a disk, there are several possibilities.

(i) The file is New. That is, the name of the file does not refer to any existing file. At the end of the process, we have the file of records as written by the program.

(ii) The file is Extant. That is, the name of the file refers to a file previously written. In this case, there are two possibilities. Usually we replace, or overwrite, the whole file by another one and the result is the same as if the file had been a new one. It is also possible to add the new records on at the end of the old file.

Many processes require work files. These hold sequences of records which are needed at certain stages in a job but are not required to be saved at the end. Typically, the following simple processes might be performed upon a work file during one job.

1. Create the new work file called WORK1, for example.
2. Write WORK1, i.e. write a sequence of records into WORK1.
3. Read WORK1.
4. Overwrite WORK1, i.e. replace the extant file by a new sequence of records.
5. Read WORK1. This time we get the file as written in step 4.

Updating Files

The updating process is introduced at this point because of its implication for the format of internal files. Only files in internal format can participate in updating.

Updating in the LFP System can be summarized as follows. The contents of one internal file (called the Main file), modified by the contents of another internal file (called the Updating file), form a third internal file (called the New Main file). Because the updating is done sequentially, both the main file and the updating file must be in the same sequence (by item number). The new main file will also be in that sequence. The updating takes place item by item and there are three possible actions.

1. An item from the updating file is added to the main file.
2. An item in the main file is amended by one in the updating file.
3. An item is removed from the main file.

60-character set	48-character set		Collating Sequence (in Sorts etc.)
blank	blank		LOW
.	.		
<			
(	(		
+	+		
|			
&			
£	£	special significance in external format files	
*	*		
)	)		
;			
¬		"not"	
-	-	"minus" or hyphen	
/	/		
,	,	comma	
%			
_		underscore	
>			
?			
:			
#		"number" has special significance throughout	
@			
'	'	single apostrophe or "quote"	
=	=		
A to Z	A to Z	upper case letters	
0 to 9	0 to 9	numerals (0 means "zero")	HIGH

Figure 3.1 Character Sets

We are concerned here with the second activity, amending items. This is done by replacing elements as desired and leaving the remaining elements untouched. The amending item in the updating file will contain only those elements which are replacements; the others will simply be absent. There is then the problem of signifying in the amending item the removal of an element from the item in the main file. The solution is to distinguish between null elements and irrelevant (and therefore absent) elements, and an internal file in which this distinction is made is in Updating Format. Otherwise, it is in Normal Format.

The process of converting a file from external to internal format produces a file in updating format. The updating format is only significant when the file acts as an updating file. The new main file is always in normal format.

3.4 *CONSTRUCTING ITEMS FOR COMPUTER FILES*

We now describe the practical details of preparing data in the external file format. Firstly, in figure 3.1 are listed the characters available on the NUMAC printers and card punch keyboards. Printing at Durham has been limited to the 48-character set. The types of elements which it is possible to include in an item are in the table of figure 3.2

There follows a list of rules and notes for the various types of elements.

(i) Element #100 must be present in every item.

(ii) The characters #, £ and * have special significance and may not be included in any element.

(iii) One-character codes (elements #102, #203, #300, #301) should be characters chosen from a predefined code list. The code list may contain any character.

(iv) The three-character codes (elements #200 and #401 to #499) are alphabetic.

(v) The date elements (#201 and #202) can be written in various forms in the external files and are converted to a standard form for the internal files. The date 9th November 1969 can be represented by either

9/11/69
or 091169

In the first form, spacing is not significant but spaces should not occur between the digits of a number. There must be three numbers: day, month and year.

The second form must consist of 6 digits without embedded spaces; two for the day, two for the month and two for the year.

Element Tag	Field Size in Characters	Element Name	Comments (See also Appendix B)
#100	5	item number	This is the only obligatory element in an item
#101	5	replacement item number	Used only in an updating file to change an item number
#102	1	type code	Indicates the type of document, e.g. book, journal
#200	3	agent code	
#201	-	order date	) The format of these) is restricted
#202	-	date received	)
#203	1	agent report code	
#300	1	status code	Indicates the state of an order and the availability of the item
#301	1	(unused)	
#302	-	price	Format restricted
#401-#499	3	course code(s)	Indicates for which courses the item is provided
#500	≤50	date of publication	) i. There is a) restriction on) the total field) size of these) elements)
#601-#699	≤2413	author(s)	
#701-#799	≤2413	title(s)	) ii. By "author",) "title", "class) number" we really) mean heading for) filing in author,) title or class) number sequence
#801-#899	≤2413	class number(s)	
#900	≤2413	publisher	

Figure 3.2 Table of Element Types

(vi) The price element (#302) can be written in several forms and is again converted to a standard form for internal files. The "£ s. d." price £2.10.6 can be written either

2.10.6
or 021006

There must be 3 numbers in the first form: pounds, shillings and pence.

In the other form, there must be 6 digits; two for pounds, two for shillings and two for pence.

The decimal price £2.50 should be written in one of the following forms

D2.50
or 2.50

in which cases there must be two numbers, one for pounds and one for pennies

or D00250

that is the letter D followed by 5 digits, three for the pounds and two for the pennies.

Note that prices less than £1 must be written in one of the above forms. For example, 45p could be represented by

0.45
or D0.45
or D00045
or 0.9.0

(vii) The variable length fields (#500,#601-#699,#701-#799, #801-#899,#900) can contain any characters except #, £ and *, and can be of any length up to the maximum values given in figure 3.2 under the constraint that the total size of the item is limited as indicated in note (x) below.

(viii) Additional Headings

Ranges of element tags are available so that additional elements can be provided for items which should be filed in more than one place in certain sequences, i.e. which might have added entries in conventional library catalogues. The four ranges are #401 to #499 (courses), #601 to #699 (authors), #701 to #799 (titles) and #801 to #899 (class numbers). In preparing new items or amendments to items, additional elements can be included by using the next available tag in the

appropriate range. Any individual element with a tag in these ranges can be updated.

Note that there are no elements with the tags #400, #600, #700 or #800.

(ix) No two elements in one item may have the same tag.

(x) There is a limit to the size of an item in an internal file, and this restricts the total combined length of the variable fields Author, Title, Class number and Publisher to just under 2400 characters, or about twenty times the normal. In precise terms the sum of all the characters in fields 401 to 900, plus 4 times the number of authors, titles and class numbers, may not exceed 2417, or

$$L_c+L_d+L_p+\sum_e(L_e+4)\leq 2417$$

where L_c = sum of lengths of course elements (3, 6, 9 characters etc.)

L_d = length of date of publication

L_p = length of publisher

$\sum_e(L_e+4)$ = sum of lengths of author(s), title(s), class number(s) with 4 added to each.

Punching Items on Cards

We now give the rules for transferring information to the 80-column cards in external format.

(i) An element is punched as follows.

tag text £

tag is one of the element tags given in figure 3.2. It is punched as the # character followed by an appropriate 3-digit number. Spaces are allowed between the # and the number, but not embedded in the number.

text is the actual element. When the item is converted to internal format, any spaces at the beginning and end of the text will be removed. Then the element will be entered unchanged into the internally formatted item (unless it is one of the elements #201, #202 or #302 - see notes (v) and (vi) above).

£ acts as a terminating character.

Example: The following are all equivalent to a primary author field of "SMITH H." in an internal file

```
#601 SMITH H.£
#601SMITH H.£
#  601   SMITH H.   £
```

(ii) The elements of an item are punched one after another in any order whatever and, optionally, with spaces between them. The last element in an item must be followed by a * (spaces may intervene). The * acts as an end-of-item character.

(iii) If an item contains, in the syntactic place of a punched element, either

DELETE
or DELETE £

then that item is intended to cause the deletion from a file of the item with the specified element #100, or item number. All other elements in the punched item are superfluous. A "delete" item is only meaningful in a file which is destined to be an updating file.

Example: Any of the following items could be used to specify the deletion of item number "D2371".

```
#100 D2371£ DELETE £ *
#100 D2371 £ DELETE *
DELETE #100 D2371 £ *
DELETE #100 D2371£ #601 JEANS J.£ *
```

In the last item, the author element is included simply to remind us which item is being deleted; it is not used to identify the item by the computer.

(iv) In the simplest case, when punching a file in external format, we ignore the card boundaries and imagine that the cards are stuck together in a long strip. If the end of a card comes in the middle of a word, we just carry on in column 1 of the next card. There are occasions when it is useful (or wise!) to have the cards numbered and in that case the numbers are punched in the last few columns of the cards. When laying out the elements and items, the card columns containing the numbers are ignored; we imagine that we have, for example, 72-column cards instead of 80-column cards.

Appendix B shows how items might be punched. The appendix also contains copies of the instructions as used in Durham University by library staff writing the forms and by card punch operators transferring the data to cards.

4

FILE MAINTENANCE

Some of the LFP programs can now be described and we start with three important functions:

(i) Conversion of bibliographic files from external format to internal format, which is the tool for getting files into the machine.

(ii) Updating files in internal format.

(iii) Copying internal files either in their entirety or selectively.

The descriptions include prototype commands to invoke the programs written in the form described in Chapter 1.

4.1 *FILE CONVERSION (EXTERNAL TO INTERNAL FORMAT)*

1. Command

label FINPUT extfile column switch intfile code102 code203 code300 code301 ;

label is optional and is any name by which the command can be referred.

FINPUT is the name of the file input program, which converts the items in external format in the card file called extfile into a file of items in internal format called intfile.

extfile is an input card file name representing an external file.

column is a number not exceeding 80. It specifies the last column from which data is to be taken (e.g. 80 if the whole card is read, 72 if columns 73-80 are ignored as in the case of numbered cards).

switch is replaced, in practice, by either ON if a printed copy of the card file is required, or OFF if the printout is to be suppressed. If the switch is OFF, cards with errors are the only ones printed.

intfile is the name of the output internal file. It can be new or extant (see section 3.3).

code102 is a string of the characters which are admissible codes for element #102.

code203 is a string of the characters which are admissible codes for element #203.

code300 is a string of the characters which are admissible codes for element #300.

code301 is a string of the characters which are admissible codes for element #301.

The last four parameters are used for checking purposes.

2. Function and Notes

FINPUT reads the external file extfile item by item, performing certain checks and writing the valid items to intfile in the internal Updating format (see section 3.3).

The checks performed are as follows:

(i) Format checks, so that it is quite clear what comprises each element and item.

(ii) Element checks. Some of the elements are restricted in the form that they can take. For example, the item number (#100) must be 5 characters long and dates and prices must make sense. The codes entered in elements #102, #203, #300 and #301 can be checked against the lists which form the last four parameters of the command.

There are two special cases. If the parameter is an empty string,

'',

that is to say a string of zero characters, no checking is done on the corresponding coded element. If the parameter is a space,

' ',

then no code will be acceptable for that element, so every item with that element present will be rejected.

In the event of errors shown up by format or element checks, the remainder of the item is ignored and no corresponding item will be written to intfile. Messages are printed to describe the nature of the error.

The two files involved are of different types, one is a card file and the other is an internal file. The two file names in the FINPUT command must therefore be different.

3. Data Definition Cards

Job control cards are required to define the data-sets associated with extfile and intfile.

(i) extfile will be a card file, usually on punched cards submitted with the job; or it may be a previously created file on a disk or magnetic tape.

(ii) Space requirements of an internally formatted file

intfile is an output file which is either new or extant. If it is new, a new data-set must be created for it, which must be provided with enough space for the internal file. The space is difficult to estimate accurately in advance. It depends on how elements numbered from #401 onwards are used. The table below can be used as a rough guide, so long as the average number of #401-#499 elements (C) and the average total size of variable length elements per item (L) is known.

Table of number of items per track on a 2314 disk

C \ L	0	40	80	120	160	200	300	400
0	100	60	38	28	23	19	12.5	10
5	75	50	33	27	21.5	18	12.5	10
10	60	43	30	25	20	17.5	12.5	10
20	50	37.5	27	21.5	19	16	11.5	9.5

This table is neither complete nor perfectly reliable (it was produced by a computer simulation). If the figure obtained from the table is i items per track, and the number of items in the file is n, then let

t = nearest whole number below n/i, and let

s = nearest whole number below $\frac{n}{10i}$

If either t or s is zero, increase it to 1.

Request space as follows: SPACE=(TRK,(t,s))

Example

In the file for the Short Loan Collection in Durham University's Main Library, the average number of course codes per item is 1.13, and there are, on average, 64.1 characters of variable length information per item.

Looking at the table, the value of i is 45, roughly.

Suppose we are creating a file of 250 typical new items,

then n=250, t=5, s=1

so we require SPACE=(TRK,(5,1))

4. Computer Time

Central processor times for FINPUT vary between 5 and 10 seconds per 100 items, depending on the size of the items.

5. Completion Codes

(i) Completion code 4 if any formatting or other element errors have been made. One or more items will be missing from intfile.

(ii) Completion code 8 if anything is wrong with the definition of the files. FINPUT will not in this case process the data.

(iii) Otherwise, the completion code will be 0.

4.2 *UPDATING*

The reader is firstly referred to section 3.3 in the previous chapter, where there is an introductory discussion of the updating process.

1. Command

label UPDATE mainfile updfile newmfile switch ;

label is optional and is any name by which the command can be referred.

UPDATE is the name of the file updating program, which updates the information in the internal file called mainfile using the items in the (different) internal file called updfile to form the new contents of the internal file named newmfile.

mainfile is an input internal file name, which plays the role of main file in the updating process.

updfile is an input internal file name, which plays the role of updating file.

newmfile is the name of an output internal file, which plays the role of new main file.

switch is replaced by either ON or OFF. ON protects items already in mainfile from alteration in the updating process. OFF allows updating of existing items.

2. Function and Notes

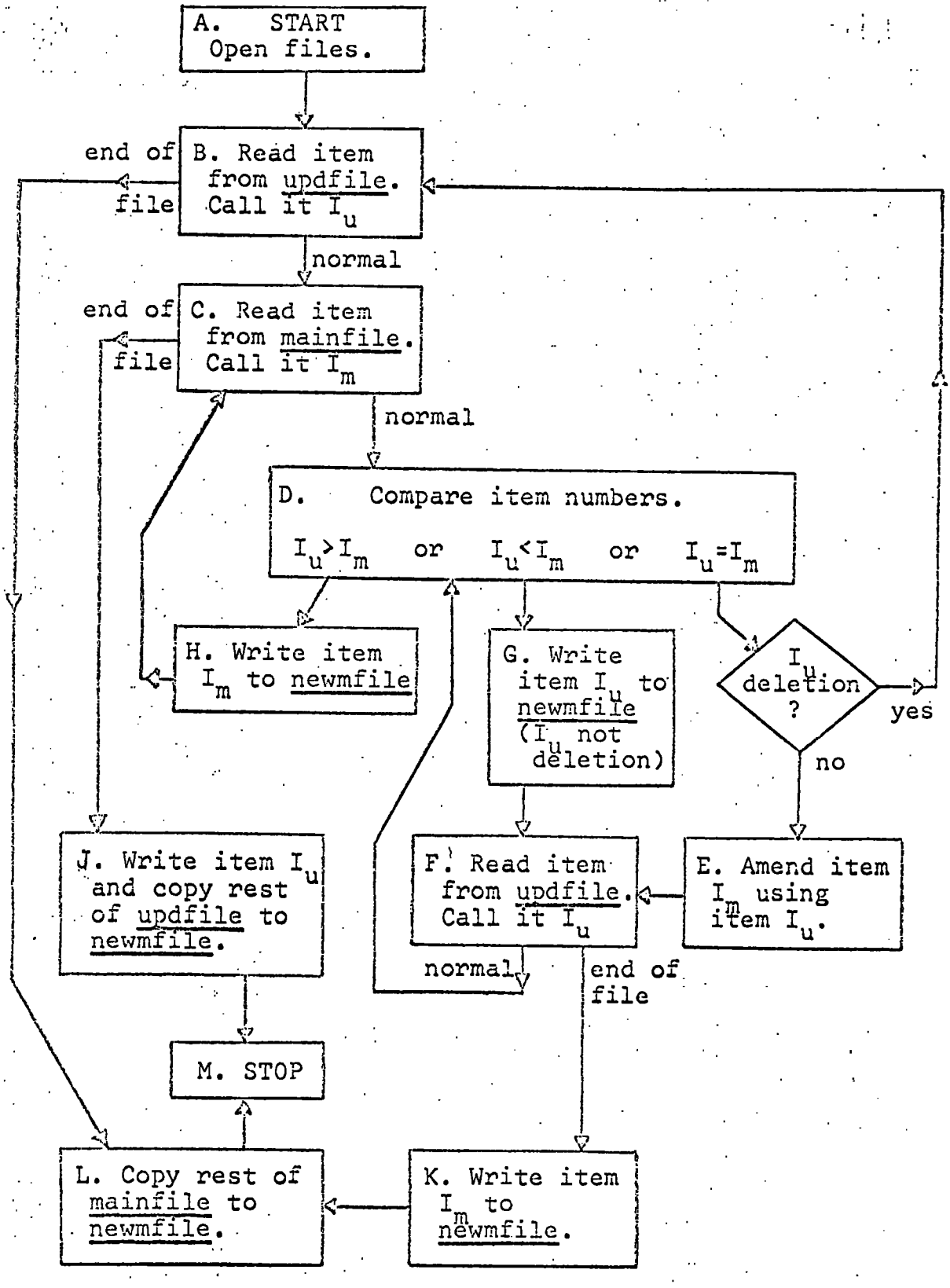
There are two aspects to the function of this program. One is the way in which the program uses the files, and the other is the process of using one internally formatted item to modify another and how this affects the preparation of items for inclusion in updating files.

We shall start with the first of these - the roles played by the files. The result of applying the updating function to two files, the main file and the updating file, is a third file, the new main file. When we say that a modification takes place to the main file, what we really mean is that when the process is successfully concluded, there will be a difference between the main file and the new main file (in terms of the prototype command, between the contents of mainfile and newmfile). We can then talk about updating the main file regardless of whether it and the new main file coexist at the end of the process.

The file used as the updating file (updfile) must be different from both of the other files (mainfile and newmfile). If mainfile is a different name from newmfile, both the main file and the new main file will exist when the updating is complete. If mainfile is the same name as newmfile, then the contents of mainfile will be replaced; the program will require a work file (see section 3.3) called WORK1 which will receive the whole updated file before it is copied back to mainfile, overwriting the previous contents.

The main file and the updating file must be in ascending item number sequence (#100). The following lettered paragraphs describe the way in which UPDATE processes the files. Each paragraph describes a step taken by the program under appropriate conditions. It starts at step A and works down the list of steps unless instructed otherwise. The flow-chart illustrates the same process.

Flow-chart of the updating process



A. Open the files mainfile and updfile so that the "next" item is initially the first item in each. (This is just to make steps B and C sensible the first time they are executed.)

B. Read the next item from file updfile; call this one I_u. If there were no more items in the file, continue with step L.

C. Read the next item from file mainfile; call this one I_m. If there were no more items in the file, continue with step J.

D. Compare the item numbers of I_u and I_m. If the item number of I_u comes before that of I_m, continue with step G. If the item number of I_u comes after that of I_m, continue with step H. If the items have the same item numbers (which is the only remaining alternative), continue with the next step.

E. If I_u is a deletion item (see note i, below), no item is written into newmfile; continue with step B. Otherwise, amend the item I_m using I_u, element by element, and proceed to the next step.

F. Read the next item from file updfile; call this one I_u. If there were no more items in the file, continue with step K. Otherwise, continue with step D.

G. (This step is only done after step D; an addition is made to the main file.) Unless I_u is a deletion item, write it in normal format into newmfile. Then continue with step F.

H. (This step is only done after step D; an item in the main file is unaltered.) Write I_m into newmfile. Then continue with step C.

J. (This step is only done after step C.) Write I_u and copy the rest of updfile (except deletion items) into newmfile. Then continue with step M.

K. (This step is only done after step F.) Write I_m into newmfile.

L. Copy rest of mainfile to newmfile.

M. Updating done. Stop.

This process effectively interfiles the main and updating files in item number sequence but with special action when an item in the updating file has the same number as one in the main file.

Notes

(i) The normal method of updating a file is to prepare an external file containing the new items and amendments to items, use FINPUT to convert it to the internal updating format and then use this file as updating file in an UPDATE command. The external format of deletion items is described near the end of section 3.4. There is a corresponding internal format which is simply equivalent to the instruction "delete item number X" when it is read from an updating file.

(ii) It can be seen from the above description of the updating process (step D) that the only element which participates in the control of it is the item number (#100). Therefore, we must remember that the only method of specifying which item we want amended or deleted is by giving the item number. The LFP System cannot cope directly with requests like "amend Modern Algebra by B.L. van der Waerden as follows . . .".

(iii) The function of switch in the UPDATE command is to enable us to protect items in mainfile from amendment or deletion when newmfile is constructed. Items in updfile which would cause amendment or deletion are ignored if switch is ON. Step E is the relevant step in the program description, and it is executed as it stands if switch is OFF. If switch is ON it is replaced by:

E. Print a warning message and proceed to the next step (i.e. F).

We normally have the switch ON if we intend only to add new items to a file. Then no harm is done if we have made a mistake in an item number in the updating file.

We now move on to the specification of amendments to items in the main file. Items are prepared in the external format containing the item number (element #100) and whichever elements require amendment. There are three possibilities:

(i) An existing element in the main file item is to be changed. In the amendment item (i.e. the item in the updating file with the same item number) we include the replacement element. For example, if item number D2317 has publisher (#900) O.U.P. and we wish to change that to OXFORD to make the item file properly, then we prepare an item as follows:

#100 D2317£ #900 OXFORD£ *

When the amendment is done, the publisher field will be changed and all other elements will be unaltered.

(ii) A new element is to be included in the main file item. We just include it in the amendment item.

There is a special case which can be illustrated by an example. Suppose that item number S0314 in the main file has no author element, that is no element in the range #601 to #699. If we use some of the LFP System facilities described later to produce an author catalogue, this item would be filed according to its title field. If we wish to include an author in the item but still have an additional entry in the author catalogue under its title, we must give the item two "author" elements, one containing the author, the other blank. Now, the only way in which a blank element can be included in one of the element ranges, like #601 to #699, is to have a non-blank element after it. So in this example, all we have to do is add a #602 element to the item, and a blank #601 element is added automatically for us. The appropriate amendment item might look like this:

```
#100 S0314£ #602 KNUTH D.E.£*
```

(iii) An element is removed from the item in the main file. This is really a special case of element replacement; the designated element is replaced by nothing. For example, to remove the agent code (#200) from item number D0937, we punch the item

```
#100 D0937£ #200 £*
```

"#200" is the tag of a null element.

There is a special situation concerning the ranges of elements, #401 to #499, #601 to #699, #701 to #799, and #801 to #899, which is related to the case discussed in note (ii) above. Suppose that item number D1370 has four course codes (#401 to #404), ABC, DEF, "blank" and GHI. If we remove the fourth one, GHI, using the item

```
#100 D1370£ #404 £*
```

then, because #403 is blank and is no longer followed by a non-blank element, #403 is also removed automatically and we are left with two codes, ABC and DEF.

3. Data Definition Cards

Job control cards are required to define the data-sets associated with mainfile, updfile, and either newmfile, if it is different from mainfile, or WORK1 if they are the same.

(i) mainfile and updfile are the names of previously created internal files.

(ii) newmfile is the name of an output file in internal format. If it is not the same as mainfile, a data-set must be provided for it with sufficient space for the updated file.

(iii) WORK1 is the name of the work file used by UPDATE when mainfile is the same as newmfile. The data-set associated with it should normally be a temporary one and should have sufficient space for the updated file. The catalogued procedure DLFPMCLG (see Appendix C) provides the user with a work file called WORK1 which is large enough initially to hold about 5,000 internally formatted items and will expand as required to a maximum capacity of about 20,000 items. When the updated file replaces the original version, the data-set containing mainfile should, of course, be large enough to accommodate new and enlarged items.

Note. The new main file, whether it has the name mainfile or something different, will be written in normal internal format.

4. Computer Time

Central processor time for UPDATE depends on the number of items in mainfile, I_1, and the number of items in updfile, I_2, as follows.

Time is approximately $0.5+0.001\times I_1+0.05\times I_2$ seconds

If, for example, I_1 is 2500 and I_2 is 200, the time required is about 13 seconds.

If newmfile is the same as mainfile, there is an extra simple copying operation which takes about 1 second per 1000 items.

5. Completion Codes

(i) Completion code 4 is set in the following circumstances.

Any #101 element is encountered. The #101 element specifies a change of item number, which might cause the new main file to be out of sequence, so the user is warned about it.

The following are considered minor errors. Processing continues after appropriate action has been taken.

An amendment made an item too large (see section 3.4). The amendment item is ignored.

A deletion or amendment is attempted when switch is ON. The amendment item is ignored.

Two or more items with the same item number (#100) occur in updfile which are not amendment items. The second and subsequent items with that number are ignored. Note that it is permitted to have several amendment items with the same item number. They will be applied one after the other to the same item.

(ii) Completion code 8 is set in either of the following cases.

The files are not properly defined. UPDATE then does no work.

Items with the same item number are found in mainfile. Processing stops and mainfile is unchanged.

(iii) Completion code 12 is set if any items are faulty in the files.

This cannot usually happen as a result of a user's error. The main file is not changed.

(iv) Otherwise the completion code will be 0.

4.3 *COPYING FILES*

1. Command

label FCOPY infile select outfile ;

label is optional and is any name by which the command can be referred.

FCOPY is the name of the internal format file copying program which reads items from the internal file infile, applies the tests specified in select and writes the items which pass the tests into the internal file outfile.

infile is an input internal file name, from which items are copied.

select is a string of no more than 128 characters (including the blanks), enclosed in quote characters. There are certain syntax rules for the contents of the string which enable it to be interpreted as a condition for selection of internally formatted items. There is a way to ask for the selection parameter to be ignored, so that the copy is total.

outfile is the name of an output internal file, into which selected items are written.

2. Function and Notes

The basic action of the FCOPY program is very simple; items are read from an internal file (infile) and selectively written, unchanged, to the internal file outfile. If the select string is completely blank or is empty, that is if select is either

' ', or '',

then no selection takes place and all the items are written into outfile.

Notes

(i) The items on outfile will be in the same sequence as they occurred in infile.

(ii) No item will be changed in any way. If the file infile is in updating format, then the copied items in outfile will also be in updating format.

(iii) The file names infile and outfile may be the same. In that case, the work file WORK1 will be required. The program will do a selective copy from infile to WORK1 and then a simple total copy back again, overwriting the previous contents of infile. This facility can be used, instead of an update with deletions, to remove from a file items with certain characteristics.

If the request is to copy a file to itself unselectively, the program will not bother to do it.*

(iv) The facilities available for selection and the syntax of the select string are also used by other programs in the system and, for that reason, are described in detail in the next section of this chapter (section 4.4).

At this point we just list the fields within the item that can be used for selection.

```
#100, item number;
#102, type code;
#200, agent code
#203, agent report code;
#300, status code
#400, the course codes,
        range #401 to #499.
```

For example, we can select items which were ordered from A. Gent Ltd. (#200) and have not yet arrived (#300) and for which the expected arrival date is in June (#203).

---

* But this does not answer the question "can machines think?".

3. Data Definition Cards

Job control cards are required to define the data-sets to hold the files infile and outfile, if it is different from infile, or WORK1, otherwise.

(i) infile is the name of a previously created internal file.

(ii) outfile is the name of an output file in internal format. If it is different from infile, a data-set must be provided (extant or new) with sufficient space for the copied items. It will certainly be no larger than infile.

(iii) WORK1 is the name of the internal work file used when outfile is the same as infile. The catalogued procedure DLFPMCLG (see Appendix C) provides a file called WORK1 with a maximum capacity of about 20,000 items.

4. Computer Time

Central processor time for FCOPY depends on the number of items in infile, the complexity of the selection specification and the number of items written to outfile. Often, the more complex the selection is, the fewer items will be selected for outfile.

On the assumption that there are about 100 characters per item in the variable length elements, the fastest copy is an unselective one at a rate of about 700 items per second. If the copy is selective, the rate will nearly always be more than 500 items read from infile per second.

If infile is the same as outfile, the selected items will be copied back from WORK1 at about 1,000 per second.

5. Completion Codes

(i) Completion code 4 is set if the user violates the rules for constructing select in Section 4.4. The copy will be done but the selection may not be what was desired.

(ii) Completion code 8 is set by more serious errors in select and by errors in defining the files. No copying is done.

(iii) Completion code 12 is set if infile contains a faultily formatted item. This is not usually the result of any user error.

(iv) Otherwise the completion code is set to 0.

4.4 *SELECTION OF ITEMS FROM FILES*

The LFP System has a sequential selection mechanism of limited scope. It is sequential because it operates only while reading a file sequentially. It can only be used on internally formatted files and its function is to either select items for processing or ignore them, according to the values of certain of their elements. The principal programs which use selection are FCOPY, which copies internal files, and PRINT, which produces formatted lists of items from internal files. If we wish to apply a selection criterion, we provide a string of characters which is interpreted as a selection specification. This section describes the facility and the rules for constructing a selection specification.

1. Syntax of Selection Specifications

A selection specification has one of the following forms. Either

' test '

or

' test & test & . . . '

In other words, it is either a single test or more than one test separated by the & character. Spaces or commas may intervene.

Notes

(i) A specification can be all blank or it can be of zero length (i.e. contain no characters at all), in which case all items will be selected because no tests will be applied.

(ii) The total length of the specification string, including all spaces and commas, must not exceed 128 characters. If it does, it is first chopped off after the 128th character and then the last test is removed if it is not syntactically correct.

test specifies a comparison to be made with each item, and takes the following form:

tag relation value

Spaces or commas may separate the three components.

tag is either #number

or just number

No spaces or commas are allowed in tag.

number is one of the following three digit numbers (they are element numbers, of course):

100
102
200
203
300
400

relation is one of the following symbols:

= (read "equal")
¬= (read "not equal")
¬ (read "not"; and exactly equivalent to ¬=)

value is one or more characters which may be any except &, space and comma. The length of value is restricted when the element number is either 100, 200 or 400, as follows:

100, length restricted to no more than 5 characters

200 and 400, length restricted to no more than 3 characters.

2. Interpretation of Selection Specifications

We shall refer to the various components described in the paragraphs on syntax above using the underlined symbolic names. Items are read from a file sequentially, and normally passed directly to the processing program. If, however, a selection specification is in effect, each item is tested using the test's and only those that "satisfy" are passed to the program.

The result of applying a test to an item is either "true" or "false". If the selection specification consists of just one test, then an item is selected if the result is true but not if the result is false. If there are several test's separated by & characters, an item is selected only if the results of the test's are all true.

We now describe how the result of a test is obtained when applied to an item in a file.

(i) When number is either 102, 203 or 300, the result depends on the value of one of the one-character coded elements, #102 (type), #203 (agent report) or #300 (status).

If relation is =, the result is true if the element is one of the characters in value and false otherwise.

If relation is either ¬= or ¬, the result is true if the element is not the same as any of the characters in value and false otherwise.

So we can say, for example, the status must be none of the following: A, J, X or Y.

#300¬=AJXY

Another example: The type code is either B or J.

102=BJ

(ii) When number is 100 or 200, selection is by element #100 (item number) or #200 (agent code). There will be up to 5 characters in value if number is 100, or up to 3 if it is 200, and if value is shorter than these maxima the comparison will be limited to however many characters are given.

For example, those items whose numbers begin with letter D can be selected, or rejected, using

#100=D or #100¬=D

(iii) When number is 400, the result depends on elements in the range #401 to #499. Let the length of value be n characters; n will be either 1, 2 or 3. The comparisons will be between value and the first n characters of the elements.

If relation is =, the result is true only if the first n characters of at least one of the #401 to #499 range elements agree with value.

If relation is ¬= or ¬, the result is true only if the first n characters of each of the elements differ from value.

For example, if we had chosen the codes in such a way that the first letter indicated a department, we might select items for mathematics courses by including the test

#400=M

As an illustration of how to combine criteria for selecting items from a file, let us construct a selection specification for getting all the items in a file which are not monographs and which have Geography department course codes and have not yet arrived from the agents.

The assumptions are that monographs have type code B (#102), that Geography codes start with the letter G and that status codes A and C both refer to orders not yet received.

To select non-monographs, we need

#102¬=B

To select Geography department material, we need

#400=G

For non-arrivals, we need

#300=AC

All three of these must be true for the items which we want, so the complete selection specification is

'#102¬=B & #300=AC & #400=G'

Note that the order in which the test's are written does not matter.

5

SORTING BIBLIOGRAPHIC FILES

In Chapter 4, the programs for file maintenance were described and it was pointed out that the central one, UPDATE, requires that the files upon which it operates are in one particular sequence, namely by item number. Apart from maintenance, however, we have little use for the item number sequence; we are far more interested in having the items in author, class number or title order, for example. Sorting a file is the process of putting its items into a predefined sequence which may be entirely different from the original.

In the LFP System, there are three programs concerned with file sequence:

(i) SORT accepts a file in any sequence and arranges its items in a specified one.

(ii) MERGE reads two files, assumed sorted in a specified sequence, and interfiles them to form a third file consisting of all the items from each of the original files.

(iii) CHKSRT reads a file and reports on whether it is in a specified sequence.

There are two aspects to each of these processes. The first is the sequencing or filing arrangement, and the second is the management of the files involved. In the LFP System these are separated in the programming. SORT, MERGE and CHKSRT are mainly file management programs and, in theory, virtually any arrangement can be "plugged into" them. Nine filing arrangements are currently implemented in the LFP System and can be used with all three programs.

5.1 *SEQUENCING ROUTINES*

For any desired filing arrangement, a subroutine can be written for the computer, which accepts two items and decides which one should precede the other in the sequence. The rules for arrangement must, of course, be absolutely precise. We do not describe how to write such a subroutine in this manual; it is a programmer's job. Such routines are suitable for use with all three of the main programs.

The sequencing routines currently available in the LFP System are shown in the table of figure 5.1. In most cases,

the sequencing field, which determines an item's position in the file, is simply the concatenation of some of the elements of the item. If an element is absent from the item it is usually replaced in the sequencing field by one or more blank characters, which file before all the others. The exceptions are the author and title elements (#601 and #701); if either of these are absent, it is just omitted from the sequencing field. So, for example, if SEQ601 is used and an item has no author element, it will be filed under its title.

Sequencing Routine Name	Sequencing Field (How constructed)		Additional items generated for SORT
SEQ100	#100	(item number)	
SEQ200	#200+#900+#601+#701	(agent,publisher)	
SEQ467	#401+#601+#701	(course,author)	in #400 range
SEQ476	#401+#701+#601	(course,title)	in #400 range
SEQ486	#401+#801+#601+#701	(course,class)	in #400 range
SEQ601	#601+#701	(author,title)	in #600 range
SEQ701	#701+#601	(title,author)	in #700 range
SEQ801	#801+#601+#701	(class,author)	in #800 range
SEQ900	#900+#601+#701	(publisher,author)	

Figure 5.1 Table of Sequencing Routines

Additional Entries

Where indicated in the right hand column of figure 5.1, sequencing routines can generate additional items during the first phase of the SORT program. These additional items are then included in the final sorted file in the appropriate positions. So we can arrange for any item to appear in more than one place in certain sequences.

Additional entries are generated in sequences where the primary filing field is the first element in one of the ranges #401 to #499, #601 to #699, #701 to #799 or #801 to #899, and an item has more than one element in that range. An extra entry is produced for each element, after the first in the range, which is present in the item up to the last non-blank

one. In these additional items, all elements other than those in the range are the same as in the original item. The elements in the range concerned will be a permutation of the elements in the main item.

Comparison Operations

When two sequencing fields have been assembled, they are compared to see which "comes first" in a file. The comparison is, in all the provided sequencing routines, a simple character comparison. The routines work along the two fields together from left to right until they come to a difference in the fields, which can be of two types.

(i) One field is shorter than the other, and the routine has come to the end of it. The shorter field then comes first.

(ii) The difference is between the two characters in corresponding positions in the two fields. The field containing the "lower" character comes first. The table in figure 3.1 of Chapter 3 shows the collating convention. Briefly, it is that special characters come before letters which come before numerals

Sample Comparisons

The symbol ^ is used to show where the first different character occurs.

(i) HOMER comes before
TOLSTOY
^

(ii) MORPHEUS comes before
MORROW
^

(iii) ANIMALS comes before
ANIMALS IN THE FARM

The difference occurs when the end of the first field is reached.

(iv) ANIMAL WORSHIP comes before
ANIMALS
^

(v) 'PARADISE LOST' comes well before
PARADISE LOST
^

5.2 *SORTING INTERNAL FILES*

1. Command

label SORT infile sortfile sequence ;

label is optional and is any name by which the command can be referred.

SORT is the name of the program which reads an internal file, infile, and sorts the items into the sequence determined by sequence, writing them into the internally formatted file sortfile.

infile is the name of an input internal file containing, in any sequence, the items to be sorted.

sortfile is the name of an output internal file into which the items from infile will be written in the specified sequence. It may contain additional items, generated by the sequencing routine.

sequence is the name of a sequencing routine. That is one of the names listed in figure 5.1.

2. Function and Notes

The function of program SORT is to arrange the items in an internal file, infile, in the order determined by the operation of the sequencing routine, sequence. The sorted file is written into sortfile which is usually, but does not have to be, different from infile.

If sortfile is the same as infile, the sorted file will replace the unsorted one.

The items will be unchanged, but some additional ones may be generated as described in section 5.1.

3. Data Definition Cards

Job control cards are required to define the data-sets associated with infile and sortfile, if it is different from infile. SORT also uses four work files called WORK1, WORK2, WORK3 and WORK4; they are all internal files.

(i) infile is the name of a previously created internal file.

(ii) sortfile is the name of an output file in internal format. If it is different from infile, a data-set must be provided with sufficient space for all the items in infile plus, possibly, some additional entries.

(iii) WORK1, WORK2, WORK3 and WORK4 are the names of the work files required by SORT. Data-sets must always be provided for these files. The catalogued procedure DLFPMCLG (see Appendix C) provides for a file called WORK1 with a maximum capacity of about 20,000 items. The space requirements are about the same for each of the work files. A typical quantity for each one would be $\frac{3}{4}$ of the space occupied by infile, but this will depend in a non-linear way on the number of items in sortfile. The most that will be required is the space of sortfile. Use the following method to calculate the space.

Suppose that infile occupies t tracks on a 2314 disk (see Section 4.1).

Let s be the nearest whole number to $\frac{3t}{4}$, and let

i be the nearest whole number to the value of $\frac{t}{12}$.

If either s or i is zero, increase it to 1.

Put SPACE=(TRK,(s,i)) on the DD cards for the work files.

4. Computer Time

Central processor time for SORT depends on the number of items written into sortfile and on the complexity of the sequencing routine. SORT is one of the most time-consuming operations, so it is important to be able to estimate the time. If the number of items in sortfile is N and the complexity of the routine is represented by a number C, the time requirement is approximately

$$C \times N \times L \text{ seconds},$$

where L is, mathematically speaking, the ceiling of $\log_2 N$ and some values are shown below.

N in the range	L	N in the range	L
5- 8	3	513- 1024	10
9- 16	4	1025- 2048	11
17- 32	5	2049- 4096	12
33- 64	6	4097- 8192	13
65-128	7	8193-16384	14
129-256	8	16385-32768	15
257-512	9	32769-65536	16

Figure 5.2 Table of ceiling of $\text{Log}_2 N$

The values of C for the sequencing routines in figure 5.1 are estimated as follows:

Sequencing Routines	C
SEQ100	0.0021
SEQ200, SEQ900	0.0050
SEQ467, SEQ476	0.0044
SEQ486	0.0052
SEQ601, SEQ701	0.0039
SEQ801	0.0051

Example

Sort a file of 2400 items into author sequence, using SEQ601, assuming that sortfile will contain 2500 items.

N=2500, C=0.0039, L=12 (from the table)

Time required is about 2500x0.0039x12 = 117 seconds.

5. Completion Codes

(i) Completion code 4 is set if infile is empty. sortfile will not be changed.

(ii) Completion code 8 is set if any of the files, including the four work files, are not properly defined. sortfile will not be changed (even if it is defined).

(iii) Completion code 12 is set if any item is faulty. This will not usually be due to any error on the part of the user.

(iv) Otherwise the completion code will be 0.

5.3 *MERGING INTERNAL FILES*

1. Command

label MERGE fileone filetwo outfile sequence ;

label is optional and is any name by which the command can be referred.

MERGE is the name of the program which reads two sorted files, fileone and filetwo, in internal format and merges the items into one sorted file, outfile.

fileone is the name of an input internal file, assumed to be already in the sequence determined by sequence.

filetwo is the name of an input internal file, different from fileone and assumed to be already in the sequence determined by sequence.

outfile is the name of an output file in internal format, which will contain all the items from both fileone and filetwo in the sequence determined by sequence.

sequence is the name of a sequencing routine; one of the names listed in figure 5.1.

2. Function and Notes

The MERGE program reads two files in internal format and combines them to form a third file which contains all the items from the original two, unchanged, without additional items and in the sequence determined by sequence. MERGE assumes that the two input files, fileone and filetwo, are already in the sequence determined by that same sequencing routine.

For example, if AUTHOR1 and AUTHOR2 are the names of two files, both of which are sorted in author sequence (using SEQ601), the command required to merge them into one file, AUTHOR3, is:

```
MERGE AUTHOR1 AUTHOR2 AUTHOR3 SEQ601;
```

Normally, three distinct files will be involved, but it is possible to have outfile the same as either fileone or filetwo and in that case MERGE writes the combined file first to the work file WORK1 and simply copies it back to the designated file.

The file names fileone and filetwo must be different. That is, you cannot merge a file with itself.

The items will not be changed in any way as they are copied to outfile. An implication of this is that if either fileone or filetwo, but not both, is in updating format, then outfile may be in updating format as a whole, yet possibly be unsuitable for updating.

3. Data Definition Cards

Job control cards are required to define the data-sets associated with files fileone, filetwo and, if it is different from both of those, outfile. If outfile is the

same as either fileone or filetwo, then a data-set will be required for WORK1, a work file.

(i) fileone is the name of a previously created internal file.

(ii) filetwo is the name of a previously created internal file.

(iii) outfile is the name of an output internal file. The data-set must be large enough to hold all the items from both fileone and filetwo. The sum of the spaces occupied by those two files will certainly be sufficient for outfile.

(iv) WORK1 is the name of a work file in internal format. The space allowance must be as for outfile above. It is only required when outfile is the same as either fileone or filetwo and whichever it is should, of course, be large enough to receive the resulting file. The catalogued procedure DLFPMCLG (see Appendix C) provides a work file WORK1 with a maximum capacity of about 20,000 items.

4. Computer Time

Central processor time for MERGE depends on the sum of the number of items in files fileone and filetwo and on the complexity of the sequencing routine. If the total number of items involved is N and the complexity of the sequencing routine is represented by K, the time requirement is approximately

K x N seconds

The values of K for the sequencing routines in figure 5.1 are estimated as follows:

Sequencing Routines	K
SEQ100	0.0025
SEQ200, SEQ900 SEQ486, SEQ801	0.0050
SEQ467, SEQ476 SEQ601, SEQ701	0.0039

The time could be significantly reduced if K is large (i.e. sequence is complex) and one of the input files is exhausted well before the other one.

If WORK1 is used, a simple copying operation is done at the end of the process, which takes about 1 second for every 1,000 items.

Example

To merge two files of 2,500 items each in author sequence, using SEQ601 takes about

0.0039 x 5000 = 19.5 seconds

5. Completion Codes

(i) Completion code 4 is not set by MERGE under any circumstances.

(ii) Completion code 8 is set if any of the files, including WORK1 if required, are not properly defined or if an illegal combination of files is specified. The merge does not take place and outfile, if defined, is unchanged.

(iii) Completion code 12 is set if any item is faulty. This will not usually result from any user error.

(iv) Otherwise the completion code will be 0.

5.4 *CHECKING SEQUENCES IN INTERNAL FILES*

1. Command

label CHKSRT infile sequence ;

label is optional and is any name by which the command can be referred.

CHKSRT is the name of the program which reads an internal file, infile, and checks that it is in the sequence determined by a sequencing routine, sequence.

infile is the name of an input internal file, which is read and checked by CHKSRT.

sequence is the name of a sequencing routine; one of the names listed in figure 5.1.

2. Function and Notes

The function of program CHKSRT is simply to read the internal file, infile, and apply the sequencing routine, sequence, to every pair of adjacent items in the file to see whether the file is in the sequence specified. The program reports the result of the check both in printed

form and in the completion code.

If the file is in sequence, the completion code is set to 0.

If the file is empty, that is if there are no items at all in it, the completion code is set to 4.

If the file is not in sequence, processing stops at the point where this condition is detected, an indication is given of where it happens and the completion code is set to 6.

In all cases, an appropriate message is printed out and in no case will the file infile be altered. As will be seen later, the completion code returned by a command can be used to control the execution of other commands, so that we can say, for example, "see if file A is in author sequence and if it is not, then sort it into author sequence".

3. Data Definition Card

A job control card is required to associate a data-set with file infile, which is the name of a previously created internal file.

4. Computer Time

Central processor time for CHKSRT depends on the number of items read, which may be less than the total number of items in infile, and the complexity of the sequencing routine, sequence. When submitting a job we must, of course, allow for the reading of the whole file. Let N be the number of items in the file and let the number S represent the complexity of sequence. The time required will be approximately

$$S \times N \text{ seconds}$$

The values of S for the sequencing routines in figure 5.1 are estimated as follows:

Sequencing Routines	S
SEQ100	0.0013
SEQ200, SEQ900 SEQ486, SEQ801	0.0035
SEQ467, SEQ476 SEQ601, SEQ701	0.0030

Example

To check a file of 2,500 items for author sequence using SEQ601 takes about

$$0.003 \times 2500 = 7.5 \text{ seconds}$$

5. Completion Codes

Some of these are described in the description of the function of the program.

(i) Completion code 0 is set if the file infile is in specified sequence.

(ii) Completion code 4 is set if the file infile is empty. This situation may or may not be regarded as successful.

(iii) Completion code 6 is set if the file infile is not in the specified sequence.

(iv) Completion code 8 is set if the file infile is not properly defined. No checking is done.

(v) Completion code 12 is set if a faulty item is encountered. This is usually not a result of an error by the user.

6

PRINTING BIBLIOGRAPHIC FILES

Printing is one of the primary functions of the Library File Processing System; there would be little point in maintaining and sorting files on magnetic disks if there were no way of displaying them visually for the benefit of library users and library staff. In the present system, display is restricted to lists produced on a high speed line-printer with the 60 characters shown in figure 3.1. Within this restriction, however, the printing facility is quite versatile, and the user of the system has moderately fine control over the appearance of the printed information.

One program is responsible for printing out internal files, namely PRINT. The program is invoked by a command which must also give the whereabouts of a set of printing instructions, or "print-control statements", prepared by the user. Broadly speaking, these instructions specify three types of information for program PRINT.

(i) The internal file, or files, to be printed.

(ii) Which items are to be included; that is an optional selection criterion.

(iii) In the printed items, which elements are to be included and how they are to be formatted.

The instructions must be contained in a card file and may, therefore, either be included in the job on punched cards or be prestored on a disk and read by PRINT from there. The user has the facility to modify his requirements easily and as often as necessary. In this chapter, we first have a description of the command, PRINT, and then an explanation of the use of the printing instructions.

6.1 *PRINT COMMAND*

1. Command

label PRINT cardfile column ;

label is optional and is any name by which the command can be referred.

PRINT is the name of the file printing program, which reads print-control statements from the card file called cardfile and prints the contents of internal files as specified in those statements.

cardfile is an input card file name. The file should contain print-control statements to specify which internal files are to be printed, and how. This file is called the "control file".

column is a number which should not exceed 80. Columns beyond that card column in the records (or cards) of cardfile will be ignored. That is, the print-control statements will be read from columns 1 to column inclusive in cardfile. The usual values of column in practice are 80 (for whole cards) and 72 (for numbered cards).

2. Function and Notes

The program PRINT operates in two main phases. The first reads instructions for printing, or print-control statements, from a control file whose name is cardfile. The types of statement and their various forms are discussed in section 6.2. If the statements are syntactically valid and not obviously nonsense, the second phase of PRINT is executed and the formatted lists are produced, normally on a line-printer. It is then possible to go back to the first phase and read another set of statements and print more lists, and so on, all within one invocation of PRINT.

The control file, cardfile, should not be confused with the internal file or files containing the items to be printed. The name(s) of the latter will be included in the statements contained in cardfile. Also, cardfile may contain a reference to another card file containing further print-control statements.

There now follow some notes on the way in which PRINT uses control files. For this purpose, we have a simple description of a control file without going into detail.

Firstly, a "set of instructions" consists of all that is needed to specify a listing; it contains

(i) One or more input internal file names,

(ii) Optionally, a selection specification, which is applied to all items read from the internal files,

(iii) Element formatting instructions.

An "execute" statement is one which, following a set of instructions, signals the end of them. It also specifies what is to be done after the files have been printed; there are three possibilities.

(i) Terminate PRINT,

(ii) Read another set of instructions from this control file,

(iii) Switch to another (named) control file and read another set of instructions from there.

A control file consists of one or more sets of instructions, each followed by an execute statement. PRINT starts by reading the first set of instructions in cardfile, printing the specified lists, and then proceeds to further sets of instructions as directed by the execute statements.

Note that, in general, once instructions and execute statements in a control file have been read, whereupon PRINT is terminated or another control file switched in, further reading of it at any stage in the same job step can only occur if it is stored on a disk (i.e. not on punched cards submitted with the job) and even then it can only be read from the beginning again. There is an exception; a special card file called CONTROL can be read in sections at different stages either during the execution of one command or during the whole job step.

3. Data Definition Cards

Job control cards are required to define the data-sets associated with cardfile and any other control files and all internal files referred to in the control files that are read by PRINT. There is a decoding facility, described in section 6.2, which requires the definition of a specially organized file of codes called SYSCODE. This is only needed if the decoding facility is actually used in the job step. A description of how to construct a file of codes can be found in Chapter 8.

(i) cardfile and other control files are card files and can be on punched cards submitted with the job or in data-sets previously created on a disk.

(ii) All internal files are previously created files.

(iii) SYSCODE is a previously created file of codes.

4. Computer Time

Central processor time will depend, for each listing operation in the control file(s), on the number of items read from the internal file(s), the complexity of the selection criterion, the number of items printed and the complexity of the formatting. No attempt will be made to give a formula. Assuming that items have about 100 characters of variable length information each, then PRINT can be expected to format about 50 items per second for printing in the worst cases.

5. Completion Codes

(i) Completion code 4 is set if suspected errors are detected in a control file.

(ii) Completion code 8 is set if errors are found in a control file or if any required file is not defined properly. Affected lists will not be printed.

(iii) Otherwise the completion code will be 0.

6.2 *PRINT-CONTROL STATEMENTS*

Program PRINT is controlled by sets of instructions entered in card files (control files). As described in the previous section (6.1), one invocation of PRINT can interpret several sets of instructions. In this section, we describe how to construct a set of instructions. Each set of instructions consists of an appropriate combination of the following types of statement.

(i) List statements specify which internal files are to be printed. Any number of files can be specified.

(ii) The Select statement is used to include a selection specification which applies to all the files mentioned in the list statements.

(iii) Heading statements are used to insert a line of text within each printed item and to print elements as headings for groups of items instead of with each item.

(iv) Format statements determine which elements are printed and in what position in the item.

(v) Execute statements, one of which must come at the end of each set of instructions, stop the interpretation phase of PRINT and specify what is to be done when the corresponding printing is complete.

1. General Considerations

The instructions are initially key-punched onto 80-column cards; later a copy may be stored in a card file on a disk. The first thing to decide is whether the whole card is going to be used for instructions or whether some columns at the end of the card will be used for card numbering. (Note that if it is intended to have PRINT read the instructions from the

special file called CONTROL, the last eight columns will always be ignored - the user has no choice.) This decision made, the print-control statements can be placed on the cards unformatted, i.e. without earmarking columns for particular portions of the statements or restricting a statement to one card only or a card to one statement only.

Now some general rules and definitions for the construction of print-control statements.

(i) The characters permitted are the 60 listed in figure 3.1, Chapter 3.

(ii) A special symbol is one of the characters ; ( ) + # These have special significance.

(iii) A string is a sequence of characters. Any character or combination of characters may occur in a string. Ordinary numbers and English words (in capitals, of course) are examples of string. Strings punched on cards must be separated from each other, for the PRINT program must recognize the beginning and end of a string. Spaces, commas and special symbol's are used to separate string's and we therefore need a way of delimiting a string which contains any of these characters. Single quotes (') are placed one at each end of the string, for example

'#300=BD & #102=J'

The quotes are not included in the internal representation of the string. We might wish to write a string with an apostrophe in it, and we do this by placing two adjacent quotes wherever we want one apostrophe and enclosing the string in quotes, for example we punch

'JOHN''S'

to get the string JOHN'S into the computer.

(iv) A comment is any sequence of characters starting with the character-pair /* and ending with the character-pair */. These pairs are regarded as composite symbols and the two characters must be in adjacent card columns. A comment is syntactically equivalent to a space and is therefore, in most contexts, ignored. It can be used to incorporate comments in the set of instructions which are for the benefit of the human reader and ignored by the computer.

(v) Commas and comment's are syntactically interchangeable with spaces and wherever one space may occur, any number of spaces may occur. So any sequence of spaces, commas and comment's is equivalent to one space as far as interpretation of the statements is concerned.

To illustrate the above general remarks, we give a short sample set of instructions as they might appear on punched cards.

```
                                                    Column 73
                                                    v
          /* THIS IS A SAMPLE */                    00000010
 LIST FILE AF01; /* AF01 IS IN AUTHOR ORDER */      00000020
 SELECT ITEMS IF '#300=BD'; /* ON THE SHELF */      00000030
5,(#601 /*AUTHOR*/,5,#701 /*TITLE*/),               00000040
    CONTINUE IN 15;                                 00000050
 END; /* EXECUTE, THEN TERMINATE PRINT */           00000060
```

The interpretation of the statements will be explained later. At this stage we make the following notes.

(i) Columns 73 to 80 of each card are used for a card number and PRINT must be instructed to ignore them.

(ii) The example is rich in comments. In practice one would rarely use so many.

(iii) PRINT encounters string's and special symbol's in the statement on cards 40 and 50 in the following order:

```
5    (  #        601    5   #
701  )  CONTINUE       IN   15  ;
```

(iv) Comments apart, the example is verbose from the computer's point of view and could be rendered:

```
LIST AF01; SELECT IF '#300=BD';                     00000010
5 (#601, 5, #701) 15; END;                          00000020
```

Several of the string's are "noise" words, without meaning for the machine but, like the comments, making the instructions more comprehensible to the human user.

2. Print-Control Statement Structure

When the interpreter section of program PRINT starts to read a statement, it examines the string's and special symbol's from left to right until it finds one which tells it what type of statement it has to interpret. Continuing its scan to the right, PRINT then looks for further information, the nature of

which depends on the identified statement type. A semicolon (which is one of the special symbol's) signifies the end of the statement and, unless it is an execute statement, PRINT then proceeds to the next statement. The string's which determine statement type are certain keywords, like LIST, SELECT and END in the example above, and numbers. The special symbol's (+ and # encountered while PRINT is trying to identify the statement type tell the program that the statement is a format statement.

The implication of this method of interpreting statements is that noise words can be inserted at various places and are ignored by the program simply because they are not what the program is looking for. We can, for example, put anything at the beginning of the statement and it will be ignored unless it is an identifying keyword or one of the things which indicates a format statement.

The ability to include noise can be confusing at first and so in this chapter we describe the statement types using a "recommended" form which, although concise, is not the briefest possible but is reasonably easy to read and understand. In the paragraphs that follow, the statements are described with the help of a simple notation. Statement prototypes are written as sequences of words and symbols. Strings in capital letters and the symbols

; ( ) + #

are punched as they stand. Underlined words in lower case are, as usual, symbolic names for strings supplied by the user in each particular application. In most of the statements, alternative forms are allowed and this is indicated in the prototypes by writing alternatives one above the other and connecting them with a brace (}) on the right. Sometimes, part of a statement may be omitted at the user's discretion. In the prototype statements, strings and symbols within brackets ([ ]) are optional. Neither the braces nor the brackets are to be included in real statements. Strings must be separated from each other by a space or its equivalent. A special symbol need not be separated from either string's or other special symbol's, although it would not be an error if it were.

3. List Statement

Prototype

$$\left\{ \begin{array}{l} \text{LIST} \\ \text{PRINT} \end{array} \right\} \left\{ \begin{array}{l} \text{FILE } \underline{\text{filename}} \\ \text{FILES } (\underline{\text{filename}} \ . \ . \ .) \end{array} \right\} ;$$

(i) filename stands for an internal file name. The user may assign different values to each occurrence of the symbol filename.

(ii) The ellipses (. . .) can be replaced by as many further file names as required.

(iii) The keyword alternatives (LIST and PRINT) have exactly the same meaning.

Examples

```
LIST FILE AF01;
PRINT FILE XYZ;
LIST FILES (LBK SBK MBK);
PRINT FILES (TOM, TOM);
```

Function

The list statement tells program PRINT which internal file or files it is to print. If a parenthesized list of files is given, the program will work through the files in the order in which they occur in the statement. The files in such a list need not be different (see the fourth example) and this provides a simple technique for getting more than one copy of a listing.

Placement

List statements can be placed anywhere in a set of instructions, and the user is not restricted to one list statement per set. All the file names mentioned in list statements throughout a set of instructions are gathered into one list of names.

Note that a set of instructions must contain at least one list statement.

4. Select Statement

Prototype

SELECT ITEMS { IF / WHEN } select ;

select is a string whose length should not exceed 128 characters. The content of select is a selection specification as described in section 4.4. If spaces or special characters are contained it must be enclosed in quotes.

Examples

```
SELECT ITEMS IF 300=BDF;

SELECT ITEMS WHEN '#102=X & #400=A';
```

Function

The select statement specifies a selection criterion to be applied to the items from all the files mentioned in list statements in the current set of instructions. Refer to section 4.4 for a description of the selection mechanism and facilities. If a set of instructions contains no select statement, all items read from the files are printed.

Placement

A set of instructions may have no more than one select statement and it does not matter where it occurs in the set. The user is not obliged to include a select statement.

5. Space Statement

Prototype

SPACE lines ;

lines is a number between 0 and 30 inclusive.

Example

SPACE 2;

Function

The space statement specifies to program PRINT the number of clear lines which are to separate printed items. lines completely blank lines will be inserted between items. If there is no space statement, the assumption will be SPACE 0; Each item will be started on a new line.

Note

Printer stationery is continuous with perforation every 11 inches. We divide output into pages by leaving a few blank lines on each side of the perforation and can then print 60 lines on each page. Program PRINT will automatically avoid splitting an item at the perforation and rather leave a few extra lines blank at the bottom of a page and start the item at the top of the next page.

Placement

A set of instructions may have no more than one space statement and it need not have one at all. The space statement may be placed anywhere in the set.

6. Specifying a Layout for Printed Items

The next few statement types which we describe are the various heading statements and the format statements and some

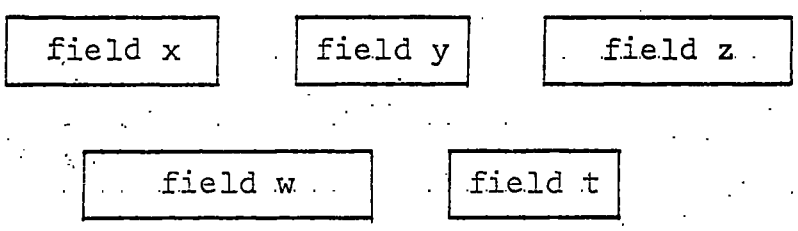
preliminary remarks and definitions are necessary. These statements specify a sequence of events which takes place in relation to every item that is selected from the internal file(s). A single statement may involve several events, which fall into four categories.

(i) Element-independent events, such as "start a new line within the printed item at this point".

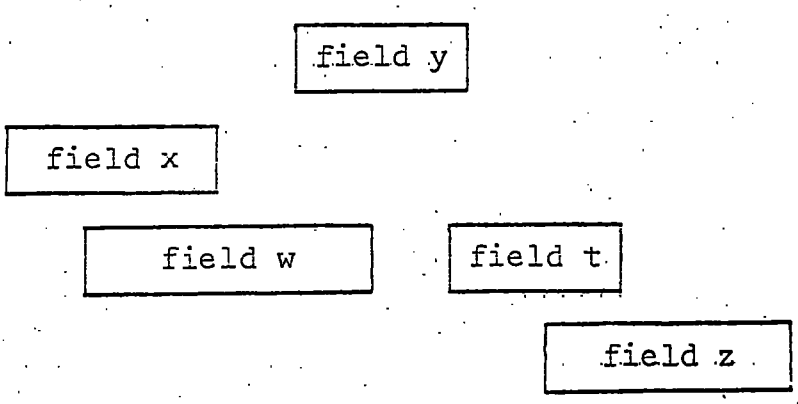
(ii) Element extraction and text composition. We can copy one or more elements from the item in the internal file and build up a piece of text.

(iii) Decoding. Certain coded elements can be converted, using a specially constructed code file, before being included in the text. We can, for example, convert the course code into a descriptive course name.

Apart from certain heading statements - the group heading statements - the order in which the statements appear in the set of instructions is the order in which they are "obeyed" when each item is processed, and is therefore important. One can imagine the computer filling in the fields on the printer paper working from left to right and downwards, but unable to backtrack. To illustrate this, let us suppose that we wish to print each item with its elements laid out in five fields as follows:



To print them correctly, the fields must be composed, in the instructions, in the order x,y,z,w,t. The effect of specifying them in the order y,x,w,t,z would be this:



Any element can be extracted from the item and included in the text to be printed, and the elements are denoted by their usual tags, for example #201 (order date), #601 (author). Most elements are printed exactly as they were originally punched in the external files, but a few elements are printed in a standard format, regardless of the way in which they were punched. The latter are the date elements, #201 and #202 and the price element, #302. Dates are printed like these examples:

9/2/70
6/10/68
23/11/69

Maximum size 8 characters.

Prices are printed as follows:

Decimal	£125.00	£ s.d.	£11.11.11
	£23.05		£12.1.0
	£5.26		£5.5.2
	50P		10.0
	Maximum size 7 characters		Maximum size 9 characters

If, in the place of an element tag in a print-control statement, the characters

#TODAY

appear, then the date on which the program is executed will be placed in the text in the same format as elements #201 and #202 as described above. The same date will be presented for formatting with each selected item as though it had been extracted as an element from the item (which, of course, it will not have been). This is of use when printing orders to booksellers, for example.

It is possible to have some elements decoded before being printed if a suitable code file is made available to program PRINT. The construction of the code file (named SYSCODE) is explained in Chapter 8. The elements that can be decoded are the one-character elements #203 (agent report) and #300 (status), the three-character elements #200 (agent) and #401 to #499 inclusive (courses) and the first character of the item number (#100). Decoding is requested by writing the word DECODED after the element tag in the print-control statement. For example:

#401 DECODED
#300 DECODED

There are three ranges of element tags, and it is possible to request the inclusion in the printed text of all elements

present in the item with tags in one of the ranges. We use special tags in the print-control statements as follows:

#400 for the range 401 to 499,
#600 for the range 601 to 699,
#700 for the range 701 to 799,
#800 for the range 801 to 899.

The text will contain all the elements in the specified range, separated by commas. For example, the tag #400 might, for one item, produce

ABX,JEF,JGP

and the tag #600 might produce

YAMEY B.S., HOBART PAPERS. SEE YAMEY B.S., HARRIS R. (ED.) SEE YAMEY B.S.

If there is a null element in the range before the last non-null one, it will be represented in the formatted text by three full stops. For example,

ABY,...,JEJ

Note that #400 DECODED is not allowed.

We now define a syntactic entity which will be used in describing some of the statements.

element has the following syntax:

num
no DECODED
TODAY

num is either one of the element numbers:

100, 101, 102, 200, 201, 203, 300, 301, 302, 401-499 incl., 500, 601-699 incl., 701-799 incl., 801-899 incl., 900, or one of the four numbers 400, 600, 700, 800, representing the aggregates of elements in one of the four ranges 401-499, 601-699, 701-799 or 801-899.

no is one of the element numbers:

100, 200, 203, 300, 401-499 incl.

The element is used to specify an extraction of data either directly from the item, or indirectly via the decoding mechanism, or from the system (in the case of #TODAY).

The next process to discuss is that of building up text for putting into a field in the printed item. The simplest possibility is to compose a piece of text using a single element. More complicated instructions are often required. We can, for example, build up text by telling the program to extract the author (#601), put 4 spaces after it, extract and add on the title (#701), add 5 spaces and, finally, add all the class numbers (#800). This whole text can then be moved into a field in the printed item. We can involve any element in the composition process and the same element may be used more than once. The user's requirements are communicated to program PRINT using the syntactic unit text in format statements.

text has the syntax:

element

(element gap element . . .)

(i) gap is a number in the range 1 to 120 inclusive. It represents the number of spaces to come between the data extracted by the element's on either side of it.

(ii) The ellipses (. . .) represent as many gap element pairs as are required. The list must end with an element and must have alternating gap's and element's throughout.

Examples of text conclude these preliminary notes.

```
#601
#401 DECODED
(#601,4,#701,5,#800)
(#TODAY,4,#201,2,#200 DECODED)
```

7. Group Heading Statements

There are two very similar statements in this category.

Prototype A

PAGE / P [start] element ;

Prototype B

LINE / L [start] element ;

(i) In each case, an abbreviation of the statement keyword to one letter is recognized.

(ii) start is a number between 1 and 120 inclusive. Its presence in the statement is optional and if it is omitted a value of 1 is assumed. start represents a position (or column) on the printer's line.

(iii) element has the syntax given on page 78.

Examples

```
PAGE 20, #401 DECODED;
LINE 5 #801;
P #900;
P 95, #TODAY;
```

Function

The main purpose of the group heading statements is to extract an element from the items and print it as a heading for the run of consecutive items which have the same value for that element. For example, to print a subject catalogue, we would firstly sort the file into class number sequence, using SEQ801 say, and then print it. We might include in the set of instructions one such as the second example above:

```
LINE 5 #801;
```

The class number would then be printed as a heading only when its value changes as the printing program reads through the file.

If a group heading statement is included in the set of instructions, it is the first to be obeyed for each item selected for printing. The data is extracted from the item and if it is identical to that which was last extracted by the group heading statement nothing further is done. Otherwise, if "DECODED" is specified, the decoding is now performed and the text is formed into a single line for printing. The text will begin in position start of the line and anything beyond position 120 in the line will be lost.

Two things are now done with this line.

(i) It is printed immediately (i.e. at the point where the element value changes in the file) either at the head of a new page if the statement follows prototype A ("PAGE"), or simply on a new line with one blank line on each side of it if a statement like prototype B ("LINE") has been used.

(ii) The heading line is also saved so that whenever a new page is started before the heading changes, the line is printed at the top of the page.

If decoding is requested and positions 95 onwards in the heading line are free after the text has been placed in it, the coded element is also placed in the line at position 95.

Placement

No more than one group heading statement can be used in a set of instructions. It can be placed anywhere in the set; it will be the first statement obeyed for each selected item regardless of its position.

8. The Format Statement

We come now to the statement which takes data from items, constructs text and formats it into a specified field on the printer paper.

Prototype

```
[ start                    ]
[ + gap                    ] text [ CONTINUE ] IN contcol ] [STOP IN stopcol];
[ + gap TAB start          ]      [ CONT     ]
```

(i) start is a number between 1 and 120 inclusive. It is a position in a printer line.

(ii) gap is a number between 1 and 120 inclusive. It is a number of spaces on a line.

(iii) If none of the alternatives in the first pair of brackets appear, then the assumption is that the first alternative is present with a value of 1 for start.

(iv) text is as defined in an earlier paragraph (page 79 Its syntax is:

```
element
(element gap element . . .)
```

(v) contcol is a number between 1 and 120 inclusive. It is a position in a printer line. If the CONTINUE-clause is omitted, contcol is assumed to be start if start is given or assumed.

(vi) stopcol is a number greater than both start and contcol, if they are specified, and not greater than 120. It is a position in a printer line. If the STOP-clause is omitted, stopcol is assumed to be 120.

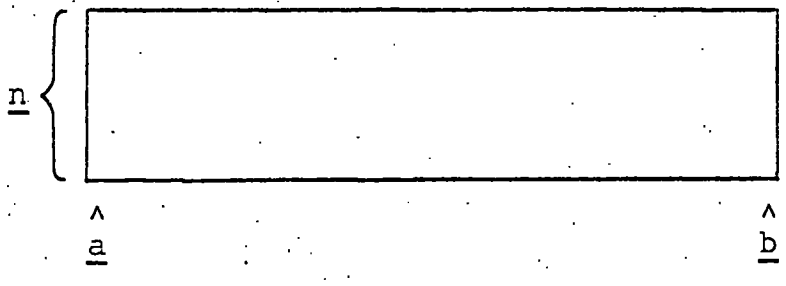
Examples

```
(a)       5, #601, CONTINUE IN 8, STOP IN 30;

(b)       #102;
     - this is exactly equivalent to
(b)       1, #102, CONT IN 1, STOP IN 120;

(c)       +4 (#601,3,#701,3,#500) STOP IN 95;

(d)       +10, TAB 30, (#701,5,#801);
    - this is equivalent to
(d)       +10, TAB 30, (#701,5,#801) CONTINUE IN 30, STOP IN 120;

(e)       4, (#100,1,#300,DECODED), STOP IN 15;
    - this is equivalent to
(e)       4, (#100,1,#300,DECODED), CONT IN 4, STOP IN 15;
```

Function

The only part which is present in all format statements is text. This specifies, for each item selected, a piece of text of virtually any length, composed mainly of elements. See pages 77-79 for a description of how texts are built up. In describing the function of the other parts of the statement, we shall assume that we have a piece of text already.

Firstly, in this explanation a "field" is a rectangular area on the printer paper containing a particular part of one or more lines. A field:



On the diagram

n is the number of lines in the field and is determined solely by the quantity of text put into it.

a is a position on the line, i.e. a column. It is the first column in the field.

b is the last column in the field.

Note that program PRINT assumes that the line is 120 characters long, i.e. the page has columns numbered 1 to 120 inclusive.

When PRINT puts some text into a field and finds that it is too long for one line, that is it will not fit into columns a to b in one piece, the program will split it at spacing or punctuation if that is possible. We define the "dynamic end" of the field as the column containing the rightmost character when the field has been filled. It is dynamic because it will vary from item to item, whereas b is a fixed limit. In fields of more than one line ($n > 1$), the dynamic end may not be the position of the last character in the first line.

At the other end of the field, a can be a fixed point, the same for all items, or it can be a floating position dependent upon previously constructed fields. a can also change during the composition of one field in a certain restricted sense. We can specify that continuation lines should start in a different column from the first line of a field; one can think of this in terms of moving the left hand side of the rectangle after the first line has been put in.

The format statement is designed to enable the user to specify a and b for one field. The sequence of format and other statements in a set of instructions then determines the layout of the printed item. The specification of b is straightforward. The value of b is the value of stopcol either as given in the STOP-clause or as assumed if the STOP-clause is omitted from the statement.

The specification of a depends on the form of the first, optional, clause in the statement. There are three possible ways of setting the value of a.

(i) start (or clause omitted in which case start is assumed to be 1).

a is set to the value of start. If that gives a column number less than the dynamic end of the last field constructed, the whole field will be moved down the page to the next free line, otherwise the field will be printed to the right of the previous field. If the text requires more than one line within the field, continuation lines will start in column contcol (remember that contcol is assumed to be the same as start if it is not specified explicitly).

(ii) + gap

a is set to the column which is gap clear spaces on from the dynamic end of the last field. So a itself is dynamically determined. Continuation lines will be started at a if either the CONTINUE-clause is omitted from the statement or the value

of a turns out to be greater than that given for contcol, otherwise they will start in contcol.

(iii) + gap TAB start

a is set to the column which is gap clear spaces on from the dynamic end of the last field only if that is beyond (arithmetically greater than) start, otherwise a is set to the value of start. This allows us to tabulate (at start) as much as possible, but at the same time to guarantee at least gap spaces between fields. Continuation lines start at contcol unless a is set to a greater value than contcol, in which case they start in column a. When the CONTINUE-clause is omitted, contcol is assumed to be the same as start.

The reader should try to work out the effects of some of the examples given above. The art of writing format statements - and, indeed, print-control statements in general - is quickly learned in a practical situation, and bears a distant relation to manipulating type for letterpress printing.

Placement

The sequence of format statements and two other types of statement yet to be described (the heading and skip statements) determines the relative positions of the fields in each item. Each of these instructions is obeyed "bearing in mind" what has preceded it.

9. Heading Statement

The name of this statement, which must not be confused with the group heading statements, should not be interpreted too literally. The product is a line of text at the beginning of the item or if we so wish at the end or at some point between.

Prototype

HEADING
HEAD } [start] string ;
H

(i) Two abbreviations of the statement keyword are recognized.

(ii) start is a number between 1 and 120 inclusive. It is a position in a printer line. If it is omitted, the value 1 is assumed.

(iii) string is any character string of length not exceeding 120. It must be enclosed in quotes if it contains any special characters or spaces.

Examples

```
HEADING 12, 'DURHAM UNIVERSITY LIBRARY';

H '          DURHAM UNIVERSITY LIBRARY';
```

The examples are equivalent to each other.

Function

The heading statement is obeyed, along with format statements, for each item selected, in the sequence in which they occur in the set of instructions. The string is printed in each item on a line to itself, starting in column start, and the line after it is left blank. If the heading statement comes before all the format statements, the string will be the first line of each printed item. Otherwise, it will occupy the next free line after the fields that have already been filled in. The example above has been used in Durham University, when printing orders to booksellers, so as to put the source of the order on each item.

Placement

The occurrence of a heading statement is optional in a set of instructions. There must be no more than one and it can be placed anywhere in the set. Its position relative to format and skip statements is important as described above.

10. Skip Statement

Prototype

```
SKIP  }
      } [lines] ;
S     }
```

(i) The abbreviation, S, of the keyword is recognized.

(ii) lines is a number between 1 and 29 inclusive. It represents a number of lines in the printed item. If lines is omitted from the statement, it is assumed to be 1.

Examples

```
SKIP 2;

S 3;

S;      - equivalent to SKIP 1;
```

Function

Skip statements are obeyed, for each item, in sequence with format statements. The statement means "before constructing the next field, skip to the beginning of the lines'th free line after the fields already filled". The effects will be that (lines-1) lines will be left blank in each item, and that the next field constructed will start at a position in the line which is independent of the previous fields. The first two examples above cause 1 and 2 lines, respectively, to be left blank and the last two examples simply cause the next field to be started on a new line.

Placement

A set of instructions can have several skip statements, or none at all. The number is limited because the PRINT program cannot handle printed items larger than 30 lines, including embedded blank ones. The position of skip statements in the set determines their place in the data formatting sequence.

11. Execute Statements

There are two types of execute statement, the End statement and the Go statement. They are called "execute" statements because they tell the PRINT program, among other things, to stop interpreting statements and if the set of instructions makes sense, to execute them (i.e. to get on with the actual printing).

Prototype A

END;

Prototype B

GO [(cardfile | cardfile column)] ;

(i) cardfile is the name of a card file containing print-control statements.

(ii) column is a number not exceeding 80. It is a card column number.

(iii) Suppose that the go statement is actually read by PRINT from a card file called this (columns 1 to col). If column is not specified, the value of col is assumed for it, and if cardfile is not specified, this is the assumed card file.

Examples

(Suppose that the following statements occur, separately, in card file SET, columns 1 to 80.)

```
(a)      GO (CONTROL,72);

(b)      GO (ALIST);
     - this is equivalent (in this case) to
(b)      GO (ALIST,80);

(c)      GO;
     - this is equivalent to
(c)      GO (SET,80);
```

There is, of course, no need to illustrate prototype A, the end statement.

Function

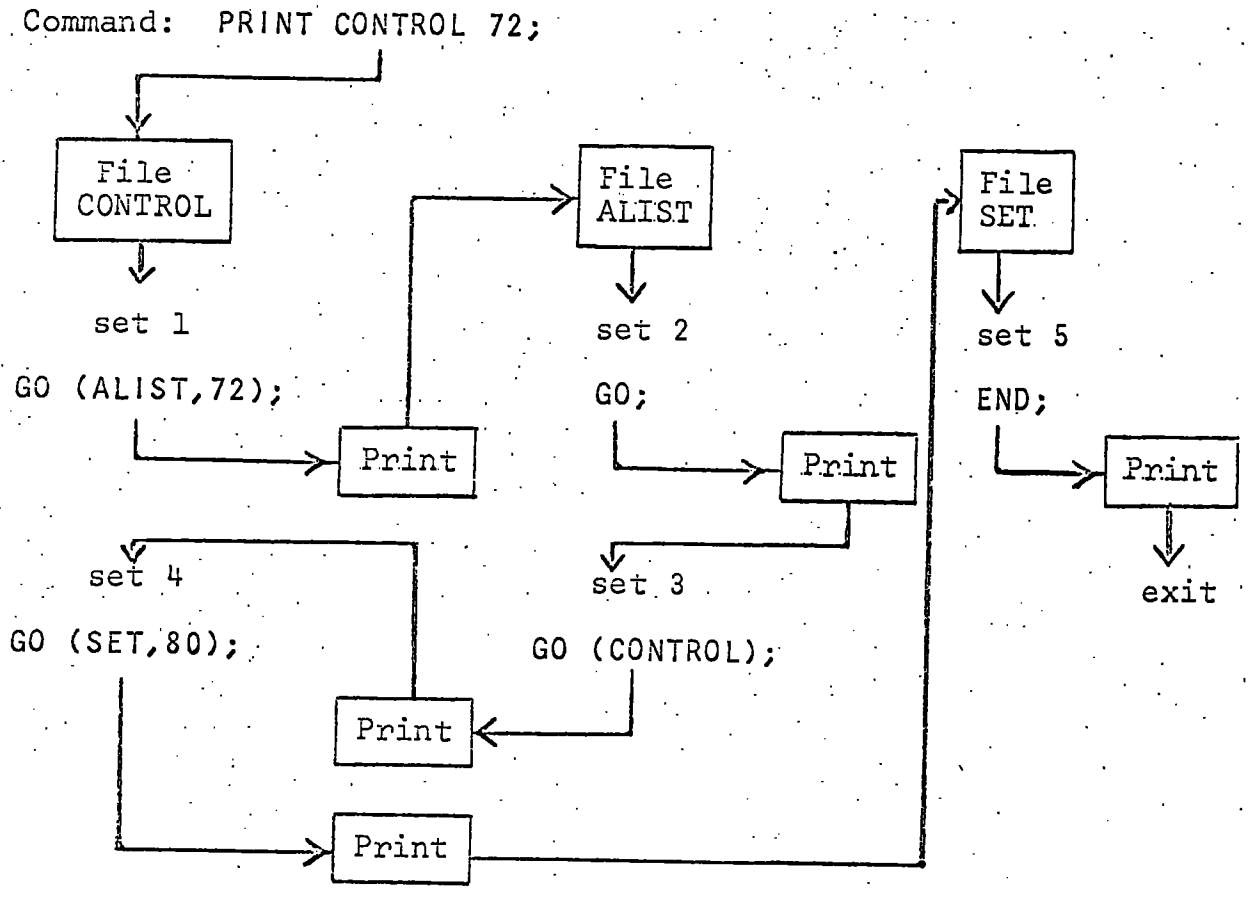
Both execute statements cause interpretation of the set of instructions to terminate, and printing of the file(s) to start if there are no serious errors in the instructions. They must therefore come at the end of sets of instructions. The other function of the execute statements is to tell PRINT what to do when the lists of items have been printed, and here they differ.

The end statement is used to terminate execution of program PRINT as invoked by the original PRINT command described in Section 6.1.

The go statement is used when further printing is required. The PRINT program is to read print-control statements for another listing from card file cardfile, columns 1 to column inclusive. If column is not specified, PRINT should read the statements from the same card columns as it did the last set. If cardfile is not specified or if cardfile is the name of the file from which the go statement was read, the PRINT program will continue reading that file at the beginning of the card immediately following the go statement. If cardfile is CONTROL, the special card file, program PRINT will continue reading it at the card after the last one read from it in the job step. If cardfile is anything else, PRINT will start reading it from the beginning.

To illustrate the use of the go statement, suppose that we have three card files, ALIST and SET stored on a disk and CONTROL entered with the job on punched cards. We can interpret several sets of instructions from all three files

with just one invocation of PRINT. For an example, follow the arrows.



Instruction sets 1 and 4 come from file CONTROL, 2 and 3 from ALIST and 5 from file SET.

Placement

Every set of instructions must have an execute statement at the end of it and that is the only place where an execute statement can occur.

6.3 *USE OF PRINT*

We illustrate the use of print-control statements with a sequence of examples, all of which print the author, title, date of publication and class number from each item of the file AFILE (which is sorted into author order). Figures 6.1, 6.2 and 6.3 each contain a set of print-control statements and a reproduction of a few items formatted accordingly. Then we give the print-control statements for a catalogue in class number order (figure 6.4) followed by a sample of the output produced by it (figure 6.5).

```
LIST FILE AFILE;
SPACE 1;  /* ALLOW BLANK LINE BETWEEN ITEMS*/
5, #601, CONT IN 7, STOP IN 24;    /*AUTHOR*/
28,#701, CONT IN 30, STOP IN 63;   /*TITLE*/
67,#500, STOP IN 75;                /*DATE*/
80,#801, STOP IN 95;      /*CLASS NUMBER*/
END;
```

ABEL-SMITH B. & TOWNSEND P.	POOR AND THE POOREST	1965	362.50942085
ABRAMS M.H.	MIRROR AND THE LAMP	1953	809.1
ACKLEY G.	MACROECONOMIC THEORY	1962	330.1
ADAM A.	HISTOIRE DE LA LITTERATURE FRANCAISE AU 17E SIECLE. 5V.	1948-56	840.61
ADAM A.	VERLAINE	1967	848.4
ADAMSON L. & DUNHAM H.W.	CLINICAL TREATMENT OF MALE DELINQUENTS	1956	365.937

Figure 6.1 Four tabulated columns

```
LIST FILE AFILE;
SPACE 1;
5,(#601,4,#701,3,#500,5,#801), CONT IN 15, STOP IN 95;
END;
```

ABEL-SMITH B. & TOWNSEND P. POOR AND THE POOREST 1965 362.50942085

ABRAMS M.H. MIRROR AND THE LAMP 1953 809.1

ACKLEY G. MACROECONOMIC THEORY 1962 330.1

ADAM A. HISTOIRE DE LA LITTERATURE FRANCAISE AU 17E SIECLE. 5V. 1948-56 840.61

ADAM A. VERLAINE 1967 848.4

ADAMSON L. & DUNHAM H.W. CLINICAL TREATMENT OF MALE DELINQUENTS 1956 365.937

Figure 6.2 Elements not individually tabulated

```
LIST FILE AFILE;
SPACE 1;
5,#601, CONT IN 7, STOP IN 75;
+4, TAB 22, (#701,3,#500), CONT IN 23, STOP IN 75;
80, #801, STOP IN 95;
END;
```

ABEL-SMITH B. & TOWNSEND P. POOR AND THE POOREST 1965 362.50942085

ABRAMS M.H. MIRROR AND THE LAMP 1953 809.1

ACKLEY G. MACROECONOMIC THEORY 1962 330.1

ADAM A. HISTOIRE DE LA LITTERATURE FRANCAISE AU 17E SIECLE. 5V. 1948-56 840.61

ADAM A. VERLAINE 1967 848.4

ADAMSON L. & DUNHAM H.W. CLINICAL TREATMENT OF MALE DELINQUENTS 1956 365.937

Figure 6.3 A partially tabulated listing

Figure 6.1 shows a tabulated listing. All the authors are printed in the same field, which starts in column 5, and similarly the titles, dates and class numbers each have their own field, the same for all items. With the indentation of continuation lines in the author field, it is easy to find authors on this list but it suffers from two disadvantages. Firstly, there are large gaps in the printed lines following short elements and one's eye can easily jump to another line while scanning across the page. Secondly, many entries will occupy more than one line and the whole list will be longer than necessary. As in the other examples, the format is restricted to print positions 5 to 95 inclusive so that the list fits the 12" wide folders in use in the library at Durham (a guillotine is applied to the right hand side of the paper). Note also that we start the lines in print position 5 instead of 1. This is to allow room for binding.

One way of overcoming the disadvantages of the fully tabulated format is shown in figure 6.2 Elements are joined into one piece of text before being placed in the field, so the author is the only element tabulated. The disadvantage in this case is the rather unattractive appearance of the whole page. A large indentation of overflow lines is necessary so that one's ability to scan the list for authors' names is not impaired by the intrusion on the left of class numbers and dates.

Figure 6.3 is a compromise. Authors and titles are closer together than in figure 6.1 and in most cases the title is tabulated. Note the position of the overflow line in the last item.

```
LIST FILE CFILE;  /*CLASS CATALOGUE*/
SPACE 1;
L 80,#801;  /*HEADING ON RIGHT TO AID SEARCHING*/
5, #801, STOP IN 79;
+3, TAB 15,#601, CONT IN 16, STOP IN 79;  /*AUTHOR*/
+3, TAB 35,#701, STOP IN 79;              /*TITLE*/
END;
```

Figure 6.4 Print-control statements for a catalogue in class number order. A sample print-out using this set of instructions is displayed in figure 6.5

For further examples of the use of print-control statements, the reader is referred to page 120 in Chapter 7, where a set is given which is intended for a file in course code order and prints the courses as headings (decoded), and to page 152, which contains a set of instructions for printing orders for dispatch to agents.

301

301 SPENCER H. PRINCIPLES OF SOCIOLOGY.ED.ANDRLSKI S.

301 STARK W. FUNDAMENTAL FORMS OF SOCIAL THOUGHT

301 WEBER M. ECONOMY AND SOCIETY. 3V.

301 WEBER M. THEORY OF SOCIAL AND ECONOMIC ORGANISATION. ED.T.PARSONS

301 WELFORD A.T. AND OTHERS (EDS.) SOCIETY. PROBLEMS AND METHODS OF STUDY. REV. ED.

301 WILSON L. & KOLB W.L. SOCIOLOGICAL ANALYSIS

301 WINCH P. IDEA OF A SOCIAL SCIENCE

301 WOLFF K.H.(ED.) GEORG SIMMEL 1858-1918

301.01

301.01 BLACK M. (ED.) SOCIAL THEORIES OF TALCOTT PARSONS

301.01 COHEN P.S. MODERN SOCIAL THEORY

301.01 DEMERATH N.J. & PETERSON R.A.(EDS.) SYSTEM, CHANGE, AND CONFLICT

301.01 GIDDENS A POWER IN THE SOCIAL THEORIES OF TALLOTT PARSONS

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301.04

301.04 BOBBS-MERRILL BOBBS-MERRILL REPRINTS IN THE SOCIAL SCIENCES (SERIES 'S'-SEE SEPERATE CATALOGUE FOR DETAILS)

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301.070944 WOLFF K.H. EMILE DURKHEIM 1858-1917

301.072

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Figure 6.5 Sample Printout (using instructions in figure 6.4)

7

HOW TO USE THE LIBRARY FILE PROCESSING SYSTEM

The most frequently used programs in the LFP System have now been described. Here is a list of them:

(i) FINPUT converts an external file (on cards for example) to internal, updating format.

(ii) UPDATE modifies one internal file, using the contents of another.

(iii) FCOPY copies internal files, either in whole or selectively.

(iv) SORT arranges an internal file in a specified order. There is a collection of sequencing routines built into the system.

(v) MERGE interfiles two previously sorted internal files to produce one file.

(vi) CHKSRT checks an internal file to see if it is in a specified order.

(vii) PRINT reads the user's directives from control (card) files and prints formatted lists of items from internal files.

This chapter describes how a librarian uses the commands so as to manipulate files and print lists and catalogues. The information given is mostly specific to the LFP System, but includes some that is just special usage of the operating system (360/OS) and its facilities.

7.1 *PROGRAMS OF COMMANDS*

We can combine the above programs (and some others still to be described) in sequences, thereby achieving considerable flexibility. Users will soon accumulate standard jobs for routine operations.

Let us consider an example and build up a program of commands. The problem is to devise a standard program to update the main file. Program UPDATE works on internal files so the new items, which have been keypunched in the external format, must first be converted to internal format (using FINPUT). We might use the following command:

```
FINPUT INDATA 80 ON TEMP BJPX '' ABCDEF ' ';
```

This reads the external file INDATA (all 80 columns of the cards) and writes the internally formatted items into file TEMP. The card listing is switched ON so that we shall get a printout of all the cards in INDATA. Acceptable type-of-publication codes (#102) are B,J,P and X and acceptable status codes (#300) are A,B,C,D,E and F. Any agent report code (#203) and no #301 codes will be admitted.

```
UPDATE LBK TEMP LBK OFF;
```

uses the newly created file TEMP to update the contents of LBK, the main file. The new version of the file replaces the old. The last parameter (OFF) allows the program to alter existing items in the file LBK. UPDATE assumes that LBK and TEMP are in item number (#100) order, but it is tedious to make sure that the new external items are in the correct order, so we insert another command before the UPDATE.

```
SORT TEMP TEMP SEQ100;
```

replaces TEMP by itself, sorted into item number order.

We now have the basis for an updating program. We write a PROGRAM statement at the beginning, to give the program a name, and an END statement at the end, and the program is complete.

```
UPD1 PROGRAM;
     FINPUT INDATA 80 ON TEMP BJPX '' ABCDEF ' ';
     SORT TEMP TEMP SEQ100;
     UPDATE LBK TEMP LBK OFF;
     END;
```

The next thing to do is to prepare data definition (DD) statements for all the files used. The files mentioned explicitly are INDATA (a card file), TEMP (a new internal file which can be destroyed at the end) and LBK (an existing internal file). In addition, SORT needs four work files called WORK1, WORK2, WORK3 and WORK4, which would be created especially for the job and destroyed at the end of it. UPDATE will also use WORK1 because it is asked to overwrite the main file (see section 4.2).

When we write DD cards for TEMP and the work files for SORT, we must say how much disk space we need. We shall assume that LBK already has 3,000 items and that there are 200 items on the cards in INDATA. In section 4.1 we calculated the requirement for Durham University's items - 45 items per track on a 2314 disk volume. We should request SPACE=(TRK,(3,1)) for TEMP and (TRK,(2,1)) for the files WORK2, WORK3 and WORK4. WORK1 must be as large as LBK, (TRK,(66,6)), because it is used by UPDATE. Disk space allocation will be explained in a later section of this chapter. At this stage, we have simply applied some of the formulae given in earlier chapters.

Let us estimate the CPU time required for the whole task.

```
Time = FINPUT time  + SORT time     + UPDATE time

     = (approx.) 20 + 0.0021x200x8 + 0.5+0.001x3000
                                       +0.05x200
                                     + 3 (copy back to LBK)

     = 40 seconds
```

We now examine the place of the program in an updating routine. Clearly it cannot be all that is required because there is no provision for safeguarding the main file. Suppose, for example, that LBK is not large enough to take the new information. That will only be detected while it is being overwritten and we shall have lost the end of the file, which may contain items not included in TEMP (in fact we cannot know exactly what remains in the file without a lot of tedious searching through printouts). We must be able to recover from such disasters efficiently and one way to ensure that we can is to take a copy of the file at regular intervals on a different disk volume or a magnetic tape. The following simple program takes a back-up copy of LBK:

```
COPY PROGRAM;
     FCOPY LBK '' BACKUP;
     END;
```

To recover, we run a very similar program (LBK and BACKUP are exchanged) and then do again all the updates that have been done since the last copy was made.

There is another updating procedure which is commonly used in commercial applications of magnetic tape files. It requires three versions of the main file which are usually referred to as grandfather, father and son. One updates the son and overwrites the grandfather with the new file; the father is untouched and is thus safe. If the process is successful, we "rotate" the terminology - the grandfather is now the son, the son becomes the father and the father will be the grandfather in the next updating run. The following program might be used for this technique.

```
UPD2 PROGRAM;
     FINPUT INDATA 80 ON TEMP BJPX '' ABCDEF ' ';
     SORT TEMP TEMP SEQ100;
     UPDATE SON TEMP GRAND OFF;
     END;
```

The DD statements required are similar to those for UPD1, but we must permute statements for the files SON and GRAND. Suppose that A, B and C are the names of the data-sets on disk holding the three versions of the file. The

files (SON and GRAND) should be defined as follows:

File Name	Data-set names		
	Jobs 1,4,7,etc.	Jobs 2,5,8,etc.	Jobs 3,6,9,etc.
SON	C	A	B
GRAND	A	B	C

Obviously, an error such as forgetting to change the DD cards between updates can wreak havoc. We must also remember which (of A, B and C) is currently the son so that up-to-date catalogues and lists are produced.

In Durham, the first method is used (programs like UPD1 and COPY). Using the catalogued procedure DLFPMCLG (see Appendix C), the job to run UPD1 consists of 17 cards apart from the cards in INDATA, and we would keep them as a standard job to use over and over again. Even so, there are various modifications which we might wish to make for some runs.

For example, if some of the item numbers (#100) have been changed using element #101, the file LBK may no longer be in order and we shall have to sort the main file. The following command, placed after the UPDATE command, tells us whether LBK is in item number order.

```
CHKSRT LBK SEQ100;
```

We can then submit a job to sort the file into item number order if necessary. We could do it all in one job by sorting the file in any case but on a file of 3,000 items about 75 seconds of CPU time would be wasted if it happened to be in order already. It can still be made into a single program by using a conditional statement. Such a statement tests the completion code set by a previously executed command and accordingly continues with or passes over the next command.

It will be recalled that CHKSRT not only prints the result of its check but also communicates it in the completion code. The codes and their meaning are:

(i) 0. File in sequence

(ii) 4. File empty (i.e. no items)

(iii) 6. File not in sequence

(iv) 8 and 12. Errors

We would wish to sort LBK only if the CHKSRT program finished with code 6. The CHKSRT command in the following modified program is labelled so that it can be referred to.

```
UPD1A PROGRAM;
      FINPUT INDATA 80 ON TEMP BJPX '' ABCDEF ' ';
      SORT TEMP SEQ100;
      UPDATE LBK TEMP LBK OFF;
  CHK CHKSRT LBK SEQ100;
      IF CHK = 6;
      SORT LBK LBK SEQ100;
      END;
```

DD cards are required for the same files as before, but WORK2, WORK3 and WORK4 must be allocated more space since they might now be used for the second SORT command.

In the next section we shall deal with the precise rules for writing commands and assembling them into programs.

7.2 *THE LIBRARY FILE PROGRAM GENERATOR*

A program of commands such as those appearing in section 7.1 is the data for the program generator, which outputs two card files. These contain the generator's products, namely:

(i) A PL/1 program which calls other, previously written programs to obey the commands and which handles completion code testing, and

(ii) Control statements for the Linkage Editor, which specify a program structure to economize on the core storage used by the final library file program.

Normally these card files are used in the same job, being written into temporary data-sets on a disk volume and removed before the end of the job. In Durham University a catalogued procedure (see section 2.4) is used and files are passed automatically to the PL/1 compiler and linkage editor programs. Appendix C contains a copy of the catalogued procedure (DLFPMCLG) and a brief explanation.

The rest of this section is concerned with the syntax of commands and other statements and the rules for constructing programs. The program generator will print messages describing any errors and warning of possible errors. It is necessary to inhibit execution of the later job steps (PL/1 compilation, linkage editing and execution) if errors have been detected in the command program, because no PL/1 program would be generated in that case. The catalogued procedure DLFPMCLG controls the execution of job steps

according to the outcome of previous steps.

1. Syntactic Units

As in the print-control language described in Chapter 6, three types of syntactic unit are recognized in the LFP System command language and with the exception of symbols with special meaning, they have the same syntax in the two languages.

(i) A symbol is either one of the characters

; = ¬ < >

or one of the following pairs of characters (always punched in adjacent card columns)

<= >= ¬< ¬> ¬=

(ii) A string is a sequence of characters. Any character may occur in a string. Strings are separated from each other by one or more spaces or their equivalent (see iv below). A symbol need not be separated from a string. Single quotes (') are used, one at each end, to delimit a string which contains a space (or equivalent) or a symbol or a quote (which would be represented by two adjacent quotes). The following are string's:

UPDATE

'#300=DEF' - quotes needed because it contains =

' ' - a blank string

'' - the empty string

(iii) A comment is any sequence of characters starting with the pair of characters /* and ending with the character-pair */. The characters in these pairs must be punched in adjacent card columns. A comment is treated like a space, so it can be used to write comments which are ignored by the program generator.

(iv) Commas and comment's are exactly equivalent to spaces and wherever one space may appear, we may write any combination of commas, spaces and comment's.

2. Commands

In general, the form of a command is as follows:

[label] progname parlist ;

label is optional (this is indicated by the square brackets which are not punched, of course). It is a name given by the user to the command for reference purposes and consists of up to 6 letters or digits without embedded spaces. If a command is labelled, label must be punched between card columns 2 and 7 inclusive. No two statements in a program may have the same label.

progname is the name of one of the task programs provided in the LFP System. The full list is given in the left hand column of figure 7.1.

parlist is a list of strings, called parameters, supplied by the user for his particular application. Each task program requires a fixed number of parameters, each of a certain type. They must always be supplied in the same order. Figure 7.1 gives the number of parameters required in each command. The descriptions of the programs (Chapters 4,5,6,8 and 9) include explanations of the meaning of the parameters. Syntactically, they fall into five categories. Figure 7.1 contains a list of parameter types for each command.

(i) File names. These must be strings of from 1 to 7 letters or digits, the first of which must be a letter.

(ii) Strings. Any string is syntactically valid for this type of parameter. The content will depend on what is required by the program (it might for example be a selection specification).

(iii) Numbers. These are strings consisting entirely of digits. They represent whole numbers.

(iv) Switches. There are two acceptable values - ON and OFF.

(v) Routine names. Syntactically, they are exactly like file names. They are the names of programs such as the sequencing routines listed in figure 5.1.

Note that a command must be terminated with a semicolon.

The whole command, after the optional label, is restricted to columns 8 to 72 (inclusive) of the cards. A command may extend over several cards. Each command must be started on a new card.

Program Name	Number of Parameters	Types of Parameters
BATCH	4	F N Sw F
CDLIST	1	F
CHKSRT	2	F R
CODEIN	1	F
COIND	1	F
FCOPY	3	F St F
FINPUT	8	F N Sw F St St St St
FPUNCH	2	F F
IMAGE	4	F N F Sw
MERGE	4	F F F R
PRINT	2	F N
RUNOFF	2	F N
SORT	3	F F R
UPDATE	4	F F F Sw

Key to parameter types:

F = file name
St = string
N = number
Sw = switch
R = routine name

Figure 7.1 Table of LFP System task programs

3. The Program Statement

Every program of commands must start with a program statement. The prototype follows:

$$[\underline{\text{label}}] \quad \left.\begin{matrix}\text{PROGRAM}\\ \text{PROG}\end{matrix}\right\} \ ;$$

label is an optional name given to the program by the user. The only use that is made of it in the system is that it is printed at the head of the first page of the output from the final program. The label, if present, consists of up to 6 letters or digits without embedded spaces and must be punched between card colums 2 and 7 inclusive. It must be a unique name within the program.

PROGRAM and PROG are alternatives, one of which must appear and the statement is concluded with a semicolon. The statement, after label, is restricted to colums 8 to 72 of the card.

4. The Conditional Statement

Commands are normally obeyed in the order in which they are written in the program. However, we might wish to break the sequence at some point depending on conditions arising during execution of the program. Conditions are detected for this purpose using conditional statements ("if" statements). The conditional statement prototype is as follows:

$$[\underline{\text{label}}] \quad \text{IF} \quad \left.\begin{matrix}\underline{\text{label1}}\\ \underline{\text{num1}}\end{matrix}\right\} \underline{\text{compare}} \left.\begin{matrix}\underline{\text{label2}}\\ \underline{\text{num2}}\end{matrix}\right\} \ ;$$

label is an optional name given to the statement for reference purposes. If present, it consists of up to 6 letters or digits with no embedded spaces. It must be different from the labels of all other statements and commands in the program. It should be punched between card columns 2 and 7 inclusive.

IF identifies the statement as a conditional one.

label1 and label2 represent labels of commands (i.e. among those named in figure 7.1) in the program.

num1 and num2 represent whole numbers, in other words string's consisting entirely of digits.

Note that label1 and num1 are alternatives and so are label2 and num2.

Note also that label1 (or label2) can be a number

(according to the syntax of labels) and we then have ambiguity - is the string a case of label1 or of num1? The following rule solves the problem. If a string adjacent to compare is composed entirely of digits, it is regarded as a value of num1 (or num2) only if no command or other statement in the program has that string as a label. It is considered an error if the string is the label of a statement other than a command.

compare is one of the following symbol's

=	"equal to"
¬=	"not equal to"
<	"less than"
>	"greater than"
¬<	"not less than"
¬>	"not greater than"
<=	"less than or equal to" (equivalent to ¬>)
>=	"greater than or equal to" (equivalent to ¬<)

They all represent comparison relations between two numbers.

The statement, after the optional label, is restricted to columns 8 to 72 inclusive of the card. An "if" statement must start on a new card.

The two numbers compared in a conditional statement are as follows:

(i) If num1 is used, then num1 itself; otherwise the last completion code returned by the command named label1 (if that command has not yet been executed, the code is taken to be zero).

(ii) If num2 is used, then num2 itself; otherwise the last completion code returned by the command named label2 (if that command has not yet been executed, the code is taken to be zero).

We say the last code returned because it is possible to have a command executed more than once in one run (though we rarely have occasion to do that).

An "if" statement must be followed in the program by either a command or another "if" statement or a "goto" statement (the "goto" statement is the next one to be described). The first command or "goto" statement after the conditional statement is called the dependent statement. The conditional statement

IF condition ;

means: "Execute the next statement if and only if the condition is true, otherwise continue with the statement following the dependent statement".

Examples

a)
```
CHECK CHKSRT AMEND SEQ100;
      IF CHECK=6;  /*DO SORT IF AMEND IS NOT IN ORDER*/
      SORT AMEND AMEND SEQ100;
      UPDATE LBK AMEND LBK ON;
```

In this example the conditional statement compares the completion code of the command labelled CHECK with the number 6 and the condition is true if they are equal. The dependent statement is the SORT command. This sequence of statements therefore means: "If file AMEND is not in item number order (SEQ100), sort it into that order. Then update file LBK with AMEND, only allowing new items to be added (switch is ON)".

b)
```
      PROGRAM;
    1 FCOPY LBK '#300=PT' F1;
    2 FCOPY SBK '#300=PT' F2;
    3 MERGE F1 F2 F3 SEQ100;
      IF 1 < 8;
      IF 2 < 8;
      IF 3 = 0;
      PRINT CONTROL 72;
      END;
```

This is an unnamed program which merges selected parts of two files and then prints a list of items (file CONTROL might contain instructions to print file F3, for example). There are three conditional statements and they all have the same dependent statement, namely the PRINT command. PRINT is executed if and only if all three conditions are found to be true. The condition 1 < 8 in this case means "the completion code of the command labelled 1 is less than the number 8" and not "the number 1 is less than the number 8", because 1 is the label of a command. The meaning of the conditional and dependent statements is "Execute the PRINT program if and only if the two file copies and the merge have worked without error".

5. The Goto Statement

The statement now to be described causes a break in the normal sequence of execution of commands and directs the computer to resume at another (named) point. The prototype is:

[label] GOTO label1 ;

label is an optional name given to the statement by the user. If it is present, label consists of from 1 to 6 letters or digits (no embedded blanks) punched between card columns 2 and 7 inclusive.

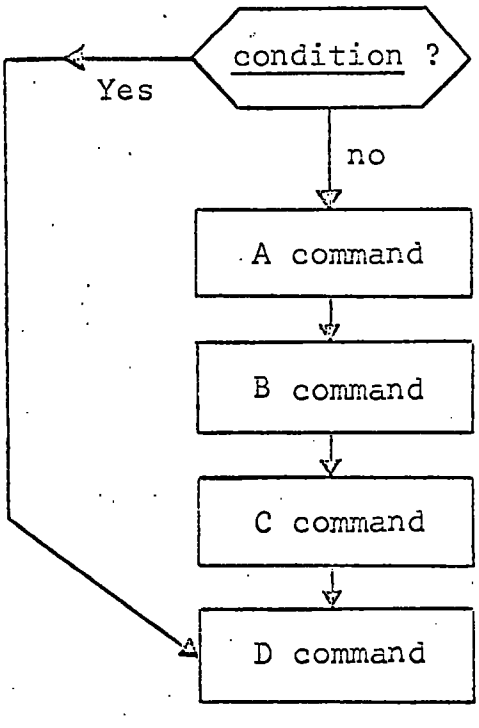
GOTO is the statement keyword. It is simply the words "go" and "to" joined together.

label1 is the label of a statement in the program. It can be the name of either a command or an "if" statement or another "goto" statement or the end statement. It may not be the label of the program statement (i.e. the name of the program).

The statement, after the optional label, is restricted to columns 8 to 72 (inclusive) of the card, and it must start on a new card.

When the statement is encountered during execution of the program, the next statement to be executed is that which has label1 as its label. "Goto" statements are most frequently used with "if" statements; there are two common situations.

(i) Under certain circumstances, we wish to skip past a few commands. A flow-chart representation of this requirement is:

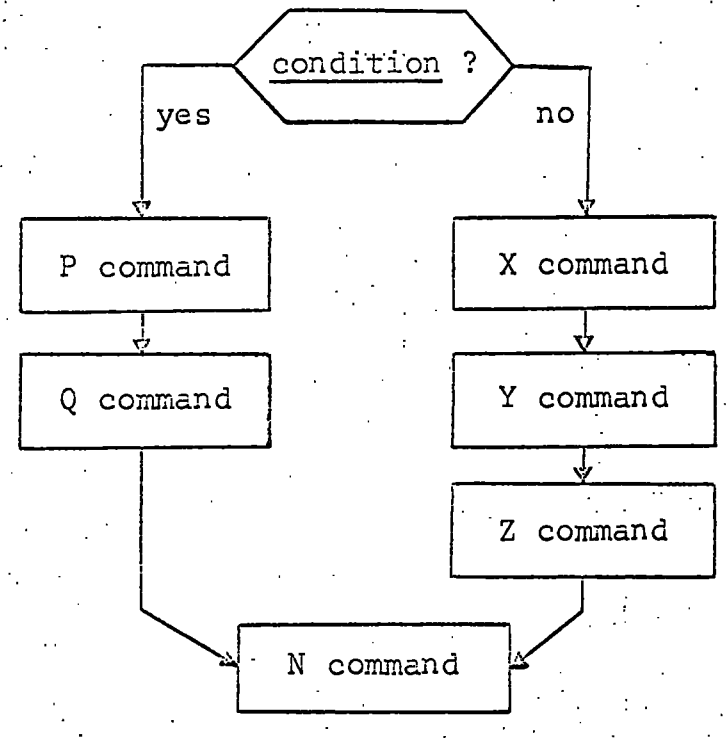


Statements to achieve it would look like this:

```
    IF condition;
    GOTO D;
A   command;
B   command;
C   command;
D   command;
```

(ii) If a certain condition holds, we wish to do one set of commands, otherwise we wish to do another set.

The flowchart:



and the statements:

```
    IF condition;
    GOTO P;
X   command;
Y   command;
Z   command;
    GOTO N;
P   command;
Q   command;
N   command;
```

Example

Let us make a temporary amendment to the program called UPD1 in section 7.1. We wish to make a backup copy of the main file (LBK) before we do the updating. We must not allow the updating to be done if the copying operation is not perfectly successful.

```
UPD1B PROGRAM;
 BKUP FCOPY LBK '' BACKUP;
      IF BKUP¬=0;  /*I.E. IF ANY ERRORS IN FCOPY*/
      GOTO EXIT;   /*     SKIP UPDATING*/
      FINPUT INDATA 80 ON TEMP BJPX '' ABCDEF ' ';
      SORT TEMP TEMP SEQ100;
      UPDATE LBK TEMP LBK OFF;
 EXIT END;
```

6. The End Statement

The reader has probably already gathered that the end statement marks the end of the program. The prototype is:

[label] END;

label is an optional name given to the statement for reference. If present, it must consist of from 1 to 6 letters or digits punched between card columns 2 and 7 inclusive.

END and the semicolon are punched anywhere in columns 8 to 72 inclusive and the statement must start on a new card.

Each program must have exactly one end statement, at the end of the program. Its function is to terminate execution.

7. Programs - Summary and Rules

A program consists of the following three parts:

(i) A program statement.

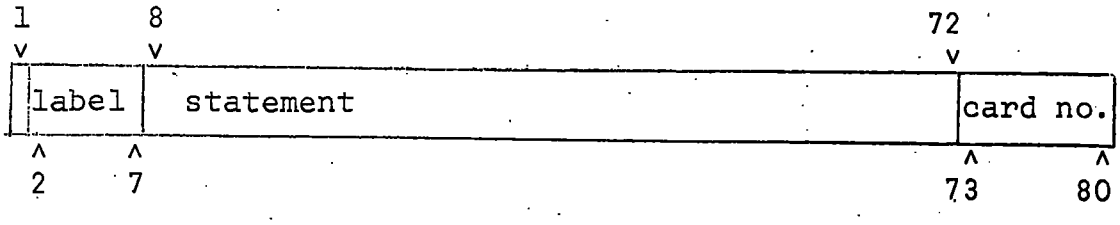
(ii) A combination of commands, "if" statements and "goto" statements arranged to accomplish the user's task.

(iii) An end statement.

Commands are executed one after the other in the order in which they occur in the program, except where that sequence is disturbed by "if" and "goto" statements.

All commands set completion codes according to conditions arising during their execution and "if" statements can be used to test the completion codes of commands which have labels.

The format of LFP System program cards is as follows:



Notes

(i) The label and the card number are optional.

(ii) A statement must begin on a new card.

(iii) A statement may continue onto as many cards as necessary. The label field on continuation cards should be blank.

(iv) Column 1 of the card has a special use which is not described here. It must normally be blank.

(v) The remarks made in section 6.2 about noise words in print-control statements are not applicable to the command language.

(vi) Labels are composed of up to 6 letters or digits with no embedded spaces. No two statements in the same program may have the same label. Labels can be referred to by "if" and "goto" statements as often as the user requires (it is not considered an error if a label is unreferenced).

7.3 *FILES AND DATA-SETS*

Users communicate their requirements (programs, peripheral devices, etc.) to the operating system in the Job Control Language (JCL) of which the Data Definition (DD) statements referred to in the command descriptions are a major part.

All LFP System programs use files of one sort or another. Most files are named by the user in his commands. There are some other files to which programs refer behind the user's back, as it were, using standard file names (for example, the work files, WORK1, etc.). These names, whether invented by the user or not, are merely symbols for channels through which information passes to and from the program. The process of File Definition is that of associating, for the duration of one job-step, a file name to a real data-set on one of the storage media accessible to the computer. The reason for this indirect method in the operating system of

using data-sets is that programs can refer to data in a device-independent way. File definition is achieved partly by information given in the program and partly by DD statements supplied as part of the job. The LFP System user is responsible only for providing DD statements containing information needed to identify the data sets.

This discussion of DD statements is limited to what is required by the LFP System user and a complete description is to be found in [119], which is a comprehensive treatment of the JCL. Also we omit details of magnetic tape handling.

Firstly, we describe the format of DD statements and the way in which they are punched into 80-column cards.

The DD Statement

//name DD parameters

The statement starts with the character / in both the first and second columns of the card.

name is that which connects the DD statement to a file in the program. When the catalogued procedure DLFPMCLG is used, the name of a file in a command is prefixed by the characters "G." to form name. There should be no embedded spaces and name must start in column 3 of the card.

E.g. //G.LBK
//G.TEMP

DD must have at least one space on either side of it. (It is called the "operation field" of the statement.)

parameters is a list of DD statement parameters, each of the form

keyword = value

E.g. UNIT=2314
DISP=(NEW,KEEP)

Parameters are separated from each other by commas (the last has no comma after it) and no blanks may occur in parameters except, as described below, when the statement will not fit onto one card. The parameters can be written in any order in the statement - the keyword identifies the type of information.

Sub-parameters are used when the value consists of

more than one piece of information. They are enclosed in parentheses.

E.g.
```
DISP=(NEW,KEEP)
DCB=(RECFM=F,LRECL=66,DSORG=DA)
```

DD statements are punched in columns 1 to 71 (inclusive) of the cards. If a statement will not fit onto one card it can be continued on as many further cards as are necessary. To continue the parameters field:

(i) Break the list after the comma following a parameter or sub-parameter, before column 72 (leaving the rest of the card blank).

(ii) Punch / in both the first and the second columns of the next card, leave at least one column blank and continue the parameter list on or before column 16.

(iii) Continue onto further cards, if necessary, in the same way.

We now describe the various parameters which the LFP System requires us to use. We shall enumerate the forms of keyword = value in parameters.

(i) DSNAME

The name of a data-set on a disk or magnetic tape.

E.g.
```
DSNAME=DUL01LBK
DSN=DUL01LBK          - DSN is a permitted
DSN=DCL03XYZ            abbreviation
```

This name is recorded on the disk or magnetic tape and if a public disk volume is used, there may be installation rules governing the choice of name. In Durham University, we use names starting with the user's job number (e.g. DUL01) followed by from 1 to 3 letters or digits.

(ii) UNIT

This gives the type of device upon which the data-set resides.

E.g.
```
UNIT=2314             - IBM 2314 disk storage
                        facility
UNIT=(2400,,DEFER)    - used for magnetic
                        tape data-sets
```

(iii) VOLUME

The name of the disk volume or magnetic tape upon which the data-set resides or is to be created.

E.g. VOLUME=SER=UNE040
VOL=SER=UNE040 - VOL is a recognized abbreviation
VOL=SER=DUL01T

(iv) SPACE

The operating system must know how much space to allocate, on a disk volume, to a new data-set. A 2314 disk volume has 4,000 recording tracks arranged in 200 "cylinders" of 20 tracks each. Space can be requested in units of cylinders or of tracks and an incremental allocation quantity can be given.

E.g. SPACE=(TRK,10) - allocate 10 tracks

SPACE=(CYL,3) - allocate 3 cylinders (=60 tracks)

SPACE=(TRK,(20,5)) - allocate 20 tracks initially and increment it by 5 tracks at a time as the file grows

SPACE=(CYL,(2,1)) - allocate 2 cylinders initially and increment by 1 cylinder as required

The size of the data-set will be incremented no more than 15 times. If more space is still required, replace the data-set by a new, larger one.

(v) DISP

This parameter tells the operating system whether the data-set already exists or must be created and what to do with it at the end of the job-step, i.e. whether to keep it or destroy it.

DISP=(NEW,KEEP) - create a new data-set, keep it

DISP=(OLD,KEEP)) - data-set already exists,
DISP=OLD) keep it

DISP=SHR - data-set already exists, keep it. Program only reads this data set, so other jobs executing simultaneously may share it.

DISP=(OLD,DELETE) - data-set already exists, destroy it at the end of the job-step.

If a DD statement has no DISP parameter, the assumption is

DISP=(NEW,DELETE)

that is the data-set is created at the beginning of the job-step and destroyed at the end - it is a temporary, or work, data-set.

(vi) DCB

This parameter gives information about the organization of the records in the data-set. It is not often used in the LFP System because the details are built into the system's programs.

Writing DD Statements for LFP System Files

We are concerned now with data-sets in disk volumes, which we categorize firstly into three types: (i) created in a previous job and extant; (ii) new and to be saved for later jobs, and (iii) temporary, i.e. new and to be deleted at the end of the job.

(i) Existing data-sets

The DD cards for these data sets can be written without regard to the organization of the contents. The data-set name, UNIT and VOLUME are required to locate it and the DISP is needed.

Examples

```
//G.LBK DD DSN=DUL01LBK,UNIT=2314,VOL=SER=UNE110,DISP=OLD
//G.SYSCODE DD DSN=DUL01LCO,UNIT=2314,VOL=SER=UNE040,DISP=SHR
//G.SAU DD DSN=DUL01SAU,UNIT=2314,VOL=SER=UNE040,DISP=(OLD,DELETE)
```

(ii) New data-sets (to be saved)

These are data-sets which must be created before the program can write records into them. We must give them a data-set name and specify UNIT, VOLUME, SPACE and DISP. Data-sets for internally formatted bibliographic files and for card files (on disk) can be created with similar DD cards.

Examples

```
//G.SBK DD DSN=DUL01SBK,UNIT=2314,VOL=SER=UNE040,
//      SPACE=(TRK,(40,5)),DISP=(NEW,KEEP)
```

```
//G.CF DD DSN=DUL01CF,UNIT=2314,VOL=SER=UNE110,
//      SPACE=(TRK,(10,2)),DISP=(NEW,KEEP)
```

Note that a data set on disk which is used by the LFP System programs to hold a card file has a capacity of 70 card records per track.

The file of codes used by program PRINT and constructed as described in Chapter 8 is always referred to by the name SYSCODE. The DCB parameter is required when creating a new code file (the catalogued procedure DLFPMCLG supplies this) as follows:

```
DCB=(RECFM=F,LRECL=66,DSORG=DA)
```

(iii) Temporary data sets

These are data-sets needed for files created during a job but not required after the job. Such files are required by some of the programs (e.g. the work files used by SORT) and others are created at the user's discretion (e.g. TEMP, the file of amendments in program UPD1B on page 107). DD cards are constructed in the same way for internal files as for card files on disk. We must specify UNIT, VOLUME and SPACE. No data set name is required and in the absence of the DISP parameter, DISP=(NEW,DELETE) is assumed.

Example

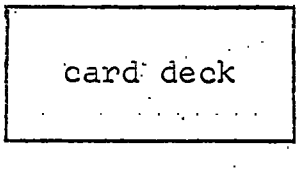
```
//G.WORK2 DD UNIT=2314,VOL=SER=UNE020,SPACE=(TRK,(15,5))
```

Special Types of DD Statement

(i) Files of cards for input

If a card file is to be entered on punched cards, the single DD statement as described above should be replaced by cards such as these:

```
//G.INDATA DD *
```




```
/*
```

Note that the program can read file INDATA only once and it may not be used for output. We can include several such files in one job.

(ii) Files of cards for output

If we wish an output card file to be punched rather than stored on a disk, the DD card to use is (e.g. for file OUTFILE)

```
//G.OUTFILE DD SYSOUT=B
```

OUTFILE could be used repeatedly in a program for card output but obviously not at all for input.

(iii) Dummy files

There is in the catalogued procedure DLFPMCLG the definition of a file called DUMMY which has the following properties when used in a program:

As an input, internal file it is empty.

As an output, internal file all items written to it are lost.

As an output, card file all cards written to it are lost.

DUMMY can be used for all of the above in one program, but it cannot be used for input card files. We can introduce an empty card file as follows:

```
//G.EMPTY DD *
/*
```

File DUMMY can be used for "dummy runs". This command, for example, checks an external file without actually storing it in internal form:

```
FINPUT EXTFILE 80 ON DUMMY BJPX '' ABCDEF ' ';
```

DLFPMCLG - What is provided in the Catalogued Procedure

Four file definitions are provided in the final job-step (step G) of the catalogued procedure DLFPMCLG.

(i) File DUMMY

(ii) File SYSPRINT for all the printer output

(iii) File SYSCODE for decoding elements for printing

(iv) File WORK1, which is simply a temporary file with an initial size of 5 cylinders (increments by 1 cylinder). WORK1 can take about 18,000 items in internal format or 28,000 records if used as a

card file. Note that, although it can be used by several commands in one program, WORK1 (or any other file except DUMMY) cannot be used both as an internal file and as a card file in the same job.

7.4 *JOB ASSEMBLY*

A complete LFP System job can now be put together. We outline the job below and then explain the parts which have not yet been discussed.

```
//          JOB card
//          EXEC card
//M.SYSIN DD *
            program of
            commands
/*
//G.etc     DD cards for all the files
            used in the program (except
            those provided in the cata-
            logued procedure) and any
            card decks for input to the
            program such as print-
            control files and new data
            items
//
```

The Library File Program Generator reads the user's program of commands from its symbolic file SYSIN in the first job-step (step M) so we must provide a DD statement with the name M.SYSIN. The PL/1 compiler and the linkage editor are executed in job-steps C and L respectively, but these are not mentioned in the job because the catalogued procedure defines them completely.

The JOB Card

The JOB card will vary considerably from one installation to another. The description here is limited to those features of the JOB card which have been commonly used in Durham University for LFP System jobs.

//jobname JOB list,source[,CLASS=x]

// is punched in columns 1 and 2 of the card.

jobname consists of the user's 5-character job number followed by up to 3 letters or digits. If the user submits more than one job at a time, each should have a distinct jobname.

E.g. the following can be used by user number DUL01

DUL01ABC
DUL01
DUL01L01

JOB is the operation field of the job statement. It must have at least one space on each side of it.

list is constructed as follows:

In its simplest form: (date,room)

where date is a 4-figure number and room is from 1 to 4 letters or digits.

E.g. (0010,C105) - might be used for a job submitted in October (month 10)

If more than 1,000 lines are to be printed, or if any cards are to be punched by the job, list is extended:

E.g. (0010,C105,,3) - allow 3,000 lines and zero cards

(0010,C104,,,200) - allow 1,000 lines and 200 cards

(0010,C105,,4,1000) - allow 4,000 lines and 1,000 cards

source is a string of no more than 20 letters, digits and full stops; spaces are not permitted. It identifies the originator of the job.

E.g. LIBRARY
R.N.ODDY

,CLASS=x is enclosed in brackets (which are not punched on the JOB card) because it is not required for every job. x represents a single letter and is called the job-class. It specifies which partitions of core storage are suitable for the job and is therefore an indication of the amount of core storage used by the job. The job-classes of LFP System jobs submitted in Durham University are A (partition size about 88,000 bytes) and C (partition size about 130,000 bytes). Larger ones are available but have not been required for any LFP System jobs submitted so far. It is not possible to give a simple rule which determines core storage requirements for a particular job. The first three steps of the job always fit into the smaller partition.

If the job-class is not given on the JOB card, A is assumed.

E.g. ,CLASS=C

Sample JOB cards

```
//DUL01T10 JOB (0003,L17),LIBRARY

//DUL01X JOB (0011,C105,,5),LIBRARY,CLASS=C

//DUL01ABC JOB (0001,LIB,,4,300),T.JONES,CLASS=A
```

The EXEC Card

The EXEC card required to invoke the catalogued procedure is as follows:

```
//[stepname] EXEC DLFPMCLG[,TIME.G=(min,sec)]
```

stepname is an optional name consisting of up to 8 letters or digits. If present, it must start in column 3 of the card and may contain no spaces.

EXEC is the statement's operation field. It must have at least one space on each side of it.

DLFPMCLG is the name of the catalogued procedure.

,TIME.G=(min,sec) is an optional field specifying a CPU time allowance for the final job-step (step G) if it is estimated that it will require more than 1 minute. min is a number of minutes and sec is a number of seconds.

Examples

```
//     EXEC DLFPMCLG

//STEPA EXEC DLFPMCLG,TIME.G=(3,0)
```

The HOLD Card

When a job's demands on various of the computer's resources exceed certain limits set by the installation management, the job must be held in the input queue until the operator can release it. To hold a job the user places a HOLD card immediately after the JOB card. The format of the HOLD card is as follows (it is not, strictly speaking, a part of the job control language):

```
/*HOLD message
```

/*HOLD is punched in columns 1 to 6 inclusive and columns 7 and 8 are left blank.

message is any brief, clear message to the operator to tell him why the job is being held. Card columns 9 to 80 inclusive can be used. It must include the job-class, even if it is A.

Examples

```
/*HOLD * * 15M ** 5000L ** CLASS=C **
```

- for a job requiring 15 minutes of CPU time and 5,000 lines printed.

```
/*HOLD ** DISK DUL01A ** CLASS=A **
```

- for a short job requiring access to the private disk volume DUL01A.

7.5 *SAMPLE JOBS*

A. A Course/Author Catalogue. Job DUL01EXA.

The first sample job is to produce a catalogue of material arranged in order of course code (#401) and, within each course, in author order (#601). The full course name is to be printed as a heading at the top of each page and a new page should be started for each new course. The listing is to include, for each item, the type of publication, the author and title. Only items in stock are to be printed (i.e. omit items unreceived, withdrawn and so on).

The data-set containing the bibliographic file is called DUL01LBK and it is stored on the public disk volume UNE040. There are approximately 3,000 items on the file in item number order. Disk volumes UNE020, UNE030, UNE040 and UNE999 can be assumed available and can be used for temporary data-sets.

1. The Program

We must first sort the file into course/author order, and then call upon the PRINT program.

```
CCAT PROGRAM;
     SORT LBK COURSE SEQ467;
     PRINT CONTROL 72;
     END;
```

The main file is referred to by the name LBK and the sorted file is called COURSE - this will be a temporary file. File CONTROL is a card file containing print-control statements designed to produce the catalogue.

2. The Data-Sets

File LBK is to be read from data-set DUL01LBK on disk volume UNE040. The program will not change its contents so it can be shared with other jobs.

File COURSE is a temporary file. Assuming that it will be 10% larger than LBK, due to additional entries, the space requirement will be (TRK,(73,7)).

Files WORK1, WORK2, WORK3 and WORK4 are required by SORT. They are temporary files and should each be given SPACE=(TRK,(55,6)). WORK1 is defined in the catalogued procedure with adequate space.

File CONTROL will be included on cards with the job (note that statements must be confined to columns 1 to 72 inclusive).

File SYSCODE is required for decoding the courses, but we do not need to supply a DD card because a suitable one is in the catalogued procedure.

3. Other Requirements

(i) Printed Output

If we make the simple assumptions that 90% of the items in the file are in stock and that 20% of the items in the catalogue will be 2-line entries, the catalogue will contain the following number of lines:

$$3300 \times \frac{90}{100} \times \frac{120}{100}$$

$$= 3564 \text{ (plus a few for the headings).}$$

Messages from the system and listings of the program and print-control statements will take about 150 lines, so our estimated total print-out is rather less than 4,000 lines long. Depending upon our confidence in the estimate, we should increase the allowance from the standard 1,000 lines to either 4,000 or 5,000 lines. In either case, the job will have to be held.

(ii) Core Storage

Any program involving PRINT must have the job-class C.

(iii) CPU Time

Total CPU time = SORT CPU time + PRINT CPU time
= (approx.) 0.0044x3300x12 + 33 seconds
= (approx.) 210 seconds (= $3\frac{1}{2}$ minutes)

We must use the TIME parameter on the EXEC card.

Note. In practice, with experience, one is able to make good estimates very quickly without doing a great deal of arithmetic.

4. The Job

```
//DUL01EXA JOB (0004,C105,,5),LIBRARY,CLASS=C
/*HOLD  *** 5000 LINES *** CLASS=C ***
//     EXEC DLFPMCLG,TIME.G=(4,0)
//M.SYSIN DD *
 CCAT  PROGRAM;
       SORT LBK COURSE SEQ467;
       PRINT CONTROL 72;
       END;
/*
//G.WORK2 DD UNIT=2314,VOL=SER=UNE020,SPACE=(TRK,(55,6))
//G.WORK3 DD UNIT=2314,VOL=SER=UNE030,SPACE=(TRK,(55,6))
//G.WORK4 DD UNIT=2314,VOL=SER=UNE040,SPACE=(TRK,(55,6))
//G.COURSE DD UNIT=2314,VOL=SER=UNE999,SPACE=(TRK,(73,7))
//G.LBK DD DSN=DUL01LBK,UNIT=2314,VOL=SER=UNE040,DISP=SHR
//G.CONTROL DD *
  LIST FILE COURSE;
  SELECT ITEMS IF '#300=BDEFMTX';  /*ITEMS IN STOCK*/
  SPACE 1;
  PAGE 20, #401 DECODED; /*COURSE NAMES AS HEADINGS*/
  (#102 /*TYPE*/ 5,#601 /*AUTHOR*/), CONT IN 9, STOP IN 95;
  +4, TAB 30, #701 /*TITLE*/, CONT IN 32, STOP IN 95;
  END;
/*
//
```

B. A Back-up Copy. Job DUL01EXB.

This example is one of the simplest jobs one can submit. We are to create a new data-set holding an exact copy of the file in data-set DUL02SBK on disk volume UNE040. The copy is also to be called DUL02SBK but is to reside on public volume UNE110. There are approximately 2,100 items on the existing file.

1. The Program

```
COPY PROG;
     FCOPY SBK1 '' SBK2;
     END;
```

SBK1 represents the old file and SBK2 the new. No selection will take place.

2. The Data-Sets

File SBK1 is to be read from data-set DUL02SBK on disk volume UNE040. It can be shared.

File SBK2 is to be stored in a new data-set on disk volume UNE110 called DUL02SBK. The data-set is to be kept at the end of the job. We must specify a SPACE parameter. At 45 items per track we need (TRK,(46,4)).

3. Other Requirements

(i) Printed Output

Messages and program listing are all that will be produced, so 1,000 lines is ample.

(ii) Core Storage

FCOPY, run on its own, fits well within the small partition, so we shall use job-class A.

(iii) CPU Time

FCOPY CPU time = (approx.) 2100/700 = 3 seconds, which is well below 1 minute.

This is a straightforward short job.

4. The Job

```
//DUL01EXB JOB (0003,C105),LIBRARY
//     EXEC DLFPMCLG
//M.SYSIN DD *
 COPY PROG;
      FCOPY SBK1 '' SBK2;
      END;
/*
//G.SBK1 DD DSN=DUL02SBK,UNIT=2314,VOL=SER=UNE040,DISP=SHR
//G.SBK2 DD DSN=DUL02SBK,UNIT=2314,VOL=SER=UNE110,
//     SPACE=(TRK,(46,4)),DISP=(NEW,KEEP)
//
```

C. An Updating Job. Job DUL01EXC.

In this final example, we use the updating program UPD1 from section 7.1 to update the file in data-set DUL01LBK on disk volume UNE040. The main file has about 3,000 items and is in item number order. New and amendment items will be contained on cards in the external format and the aim is to construct a job which can be used many times without any alteration apart from insertion of the external file.

1. The Program

```
UPD1 PROGRAM;
     FINPUT INDATA 80 ON TEMP BJFX '' ABCDEF ' ';
     SORT TEMP TEMP SEQ100;
     UPDATE LBK TEMP LBK OFF;
     END;
```

We refer to the main file as LBK. File INDATA will contain the external file and TEMP is the temporary internal equivalent to it.

2. The Data-Sets

File INDATA will be included with the job on punched cards.

File TEMP is a temporary internal file. Space is allocated, initially, for about 1,100 items.

File LBK is to be taken from the data-set called DUL01LBK on disk volume UNE040. This file will be overwritten and it cannot, therefore, be used by other jobs at the same time.

Files WORK1, WORK2, WORK3 and WORK4 are required by SORT, and a SPACE parameter compatible with that of TEMP is SPACE=(TRK,(18,2)). However, WORK1 is also required by UPDATE in this program and for that purpose the data-set must be of similar size to DUL01LBK, i.e. about 70 tracks. The definition of WORK1 in the catalogued procedure will be adequate.

3. Other Requirements

The job given below should be suitable for an updating file of up to about 1,000 items. Printed output and CPU time allowances have been chosen in such a way that the same job will be suitable for any updating file smaller than 1,000 items and a main file of about 3,000 items. Of course, the main file might increase in size significantly if a large file of new items is entered.

(i) Printed Output

The bulk of the output is produced by FINPUT as it prints a copy of the cards in INDATA. 3,000 lines are allowed.

(ii) Core Storage

UPDATE is quite a large program. We use job-class C on the first run and might be able to use A on subsequent jobs when we know how much core storage it has used.

(iii) CPU Time

A CPU time allowance of 3 minutes will be sufficient to process 1,000 external items.

4. The Job

```
//DUL01EXC JOB (0005,C105,,3),LIBRARY,CLASS=C
//SA   EXEC DLFPMCLG,TIME.G=(3,0)
//M.SYSIN DD *
 UPD1  PROGRAM;
       FINPUT INDATA 80 ON TEMP BJPX '' ABCDEF ' ';
       SORT TEMP TEMP SEQ100;
       UPDATE LBK TEMP LBK OFF;
       END;
/*
//G.WORK2 DD UNIT=2314,VOL=SER=UNE020,SPACE=(TRK,(18,2))
//G.WORK3 DD UNIT=2314,VOL=SER=UNE030,SPACE=(TRK,(18,2))
//G.WORK4 DD UNIT=2314,VOL=SER=UNE040,SPACE=(TRK,(18,2))
//G.TEMP DD UNIT=2314,VOL=SER=UNE999,SPACE=(TRK,(25,2))
//G.LBK DD DSN=DUL01LBK,VOL=SER=UNE040,UNIT=2314,DISP=OLD
//G.INDATA DD *
#100 D2594£ #300 V£ #401 JER£ #500 1969£ #601 MARTIN D.£
#701 RELIGIOUS AND THE SECULAR  #801 201.7£ *
#100 D2591£ #501 EVOLUTION AND ETHICS(ROMANES LECTURE)£ *
#100 D2573£ #300 E£ *
#100 D2553£ #401 EAF£ *

      etcetera

/*
//
```

7.6 *THE READ FACILITY*

In all the descriptions of commands up to this point the parameters have been fixed before execution of the program of commands. Suppose, for example, that we store the following program on a disk volume using program IMAGE (see section 9.4):

```
IN1 PROGRAM;
    FINPUT INDATA 80 ON NEW,BJPX,' ',ABCXY,'';
    END;
```

Whenever we use the program, we must define INDATA and NEW, on DD cards, as the input external file and the output internal file respectively. Each time, all 80 columns of the cards (records) in INDATA must be used and a copy of the card file will always be printed. The four one-character coded elements will be checked in the same way every time the program is used.

The READ facility enables us to postpone fixing the parameters until the program is actually executing - until the very last moment before they are required. Thus we can, for example, write and store a program which will convert an external file, which is either numbered in columns 73-80 or not, to internal form, printing out the card file at our discretion. The program is:

```
IN2 PROGRAM;
    FINPUT INDATA READ READ NEW,BJPX,' ',ABCXY,'';
    END;
```

The word READ, occurring in the place of a parameter in a command, instructs the computer to read the parameter from the special card file called CONTROL. The reading is done immediately before the command is obeyed. Suppose that IN2 is stored in the data-set DUL01IN2 and that we wish to convert an external file in which all 80 columns of the cards have been used for data and that no listing of the cards is required. The following job will suffice:

```
//DUL01D1A JOB (0011,C105),LIBRARY
//      EXEC DLFPMCLG,TIME.G=(2,0)
//M.SYSIN DD DSN=DUL01IN2,UNIT=2314,VOL=SER=UNE040,DISP=SHR
//G.NEW DD DSN=DUL01NBK,UNIT=2314,VOL=SER=UNE110,
//      DISP=(NEW,KEEP),SPACE=(TRK,(20,2))
//G.INDATA DD *
  #100 D2317£ #300 A£ #401 PBX£ #500 1958£

          etcetera

/*
//G.CONTROL DD *
     80;       OFF;
/*
//
```

Rules for the use of READ

(i) In the program of commands, READ may be used as many times as required in the place of file, string, number and switch types of parameter (see figure 7.1). It may not be used to read in a routine name, a command label or a program name. In the sample program IN2 above, READ is used for a number and a switch (in that order). The restrictions on the use of READ make the following two commands illegal:

```
SORT LBK OUT READ;
             ^
             should be a sequencing routine name

LAB1 READ F33;
     ^
     should be a program name
```

In the command

```
READ UPDATE LBK AMEND LBK OFF;
```

the word READ is interpreted as an ordinary label without special significance in the present context.

(ii) If READ occurs in a "goto" statement, it is taken to refer to a statement labelled "READ" - no reading is done.

(iii) READ occurring in a conditional (IF) statement always causes a read operation from file CONTROL. The program will expect to receive a number and will never use it as a label.

E.g. The statement

```
IF CHECK>READ;
```

compares the completion code set by the command labelled CHECK with the number read from CONTROL.

(iv) Whenever, during execution of the user's program the computer encounters the word READ in either a conditional statement or a command in the position of a file name, string, number or switch, it reads a new piece of data from file CONTROL. The data must appear in file CONTROL in the order in which it will be required by the executing program.

(v) The data provided on file CONTROL must be of the right type. The symbol data stands for that

which is read in response to encountering one READ during execution. The correct syntax for *data* in a particular case depends upon the type of parameter which is required. Figure 7.2 gives the various forms of *data* and, in the right hand column, the assumptions which are made in the event of syntax error.

(vi) Comments, between /* and */, are permitted with *data* and are equivalent to spaces, as usual. The comma is also treated as a space.

(vii) File CONTROL may contain both data for READ's and print-control statements. Program PRINT starts to read a set of print-control statements at the beginning of a new card.

Similarly, if a statement or command in a program requires any data from CONTROL, a new card will be started (for the statement but not for each READ in the statement).

Required parameter type	Syntax of *data*	Assumption in case of error
file name	FILE *fname*;	FILE DUMMY;
string	*string*;	''; - the empty string
number	*number*;	0; - zero
switch	ON OFF } ;	OFF;

Notes

fname is the name of a file properly defined in a DD statement.

string is any sequence of characters. To include space, comma, semicolon, enclose in quotes.

number is a whole number. Space and commas are not permitted within a *number*.

data must be terminated by a semicolon.

Spaces (or their equivalent) may occur before and after each component of *data*.

Figure 7.2. Syntax of *data* for the READ facility

8 *CODES*

In the description of print-control statements in section 6.2 a facility was mentioned for decoding some of the coded elements. By this we mean the replacement in the printout of the code by a descriptive text. The elements which can be decoded during printing are as follows:

(i) The one-character coded elements #203 (agent report) and #300 (status),

(ii) The three-character coded elements #200 (agent) and #401 to #499 inclusive (courses),

(iii) The first character of the item number (#100).

It will be recalled that if the facility is used in a printing job, a special file called SYSCODE is required, which contains information necessary for decoding the elements. This chapter explains how the user constructs a file of code translation data and concludes with the description of a command for obtaining an index of the #400 series codes (courses).

8.1 *CODES IN TREES*

The user prepares a deck of punched cards giving the codes and their meanings. The program CODEIN reads the card file and constructs a file named SYSCODE on a disk to which PRINT can refer. Before the card file can be punched, the codes must be organized in a "tree" structure and this is often best done diagrammatically. Let us start with the course codes (#401 to #499 range). They are 3-letter codes and Durham University Library is currently using about 200 different codes for undergraduate courses in some 20 departments. As we shall see, the method of preparing the code translation file suggests ways of choosing codes for courses, but for the moment we assume that the codes and their meanings are chosen and that we have a list of them.

The first thing to do is to divide the list into groups according to the first letter of the code. The following list of codes, which is a small one invented for the purpose of this explanation, is so grouped.

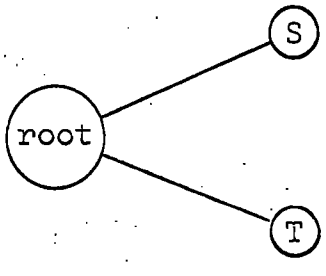
group S

SAA	economics
SBB	economics - honours (1st year)
SBC	economics - honours (2nd year)
SBD	economics - honours (3rd year)
SCA	economics - general
SFA	economics - microeconomics
SFB	economics - macroeconomics
SFC	economics - monetary

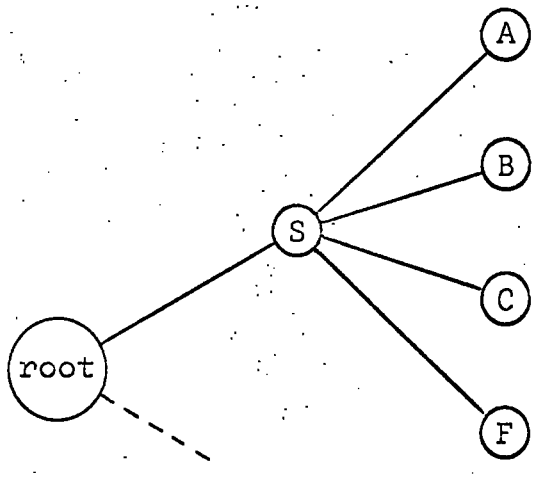
group T

TAA	mathematics
TBA	mathematics - topology
TCA	mathematics - quantum mechanics
TFA	mathematics - honours (1st year)
TFB	mathematics - honours (2nd year)
TFC	mathematics - honours (3rd year)
TGA	computing
TGB	computing - programming
TGC	computing - compilers
TGD	computing - business applications

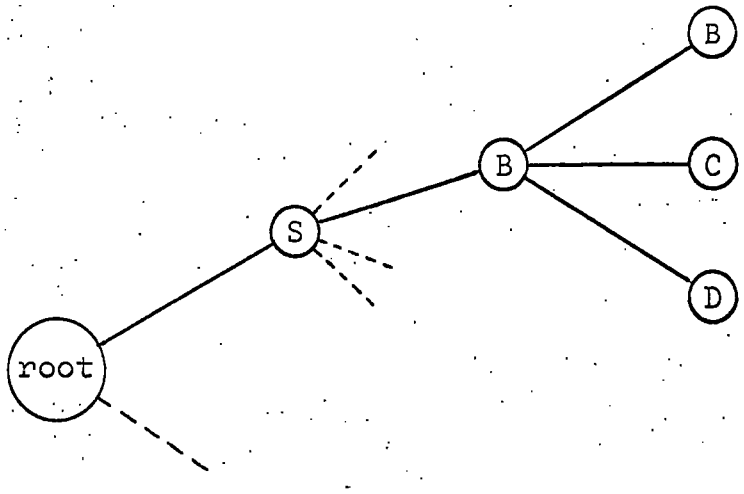
We now draw the root of the tree and the first level of nodes - in this case there are two, one each for the letters S and T.



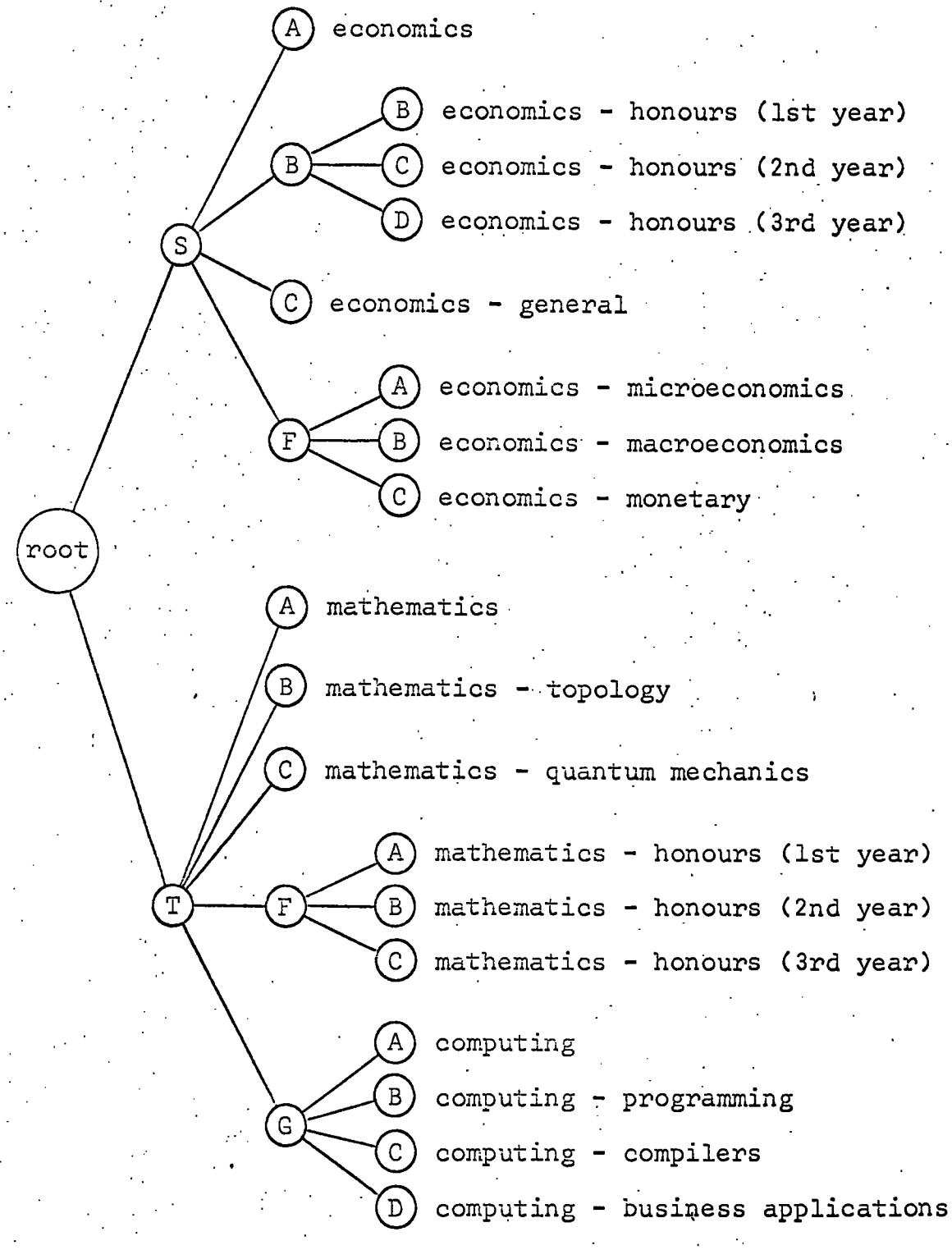
Within each major group (of more than one code) in the list, further subdivisions are made according to the second letter in the code and the next level of nodes are drawn.



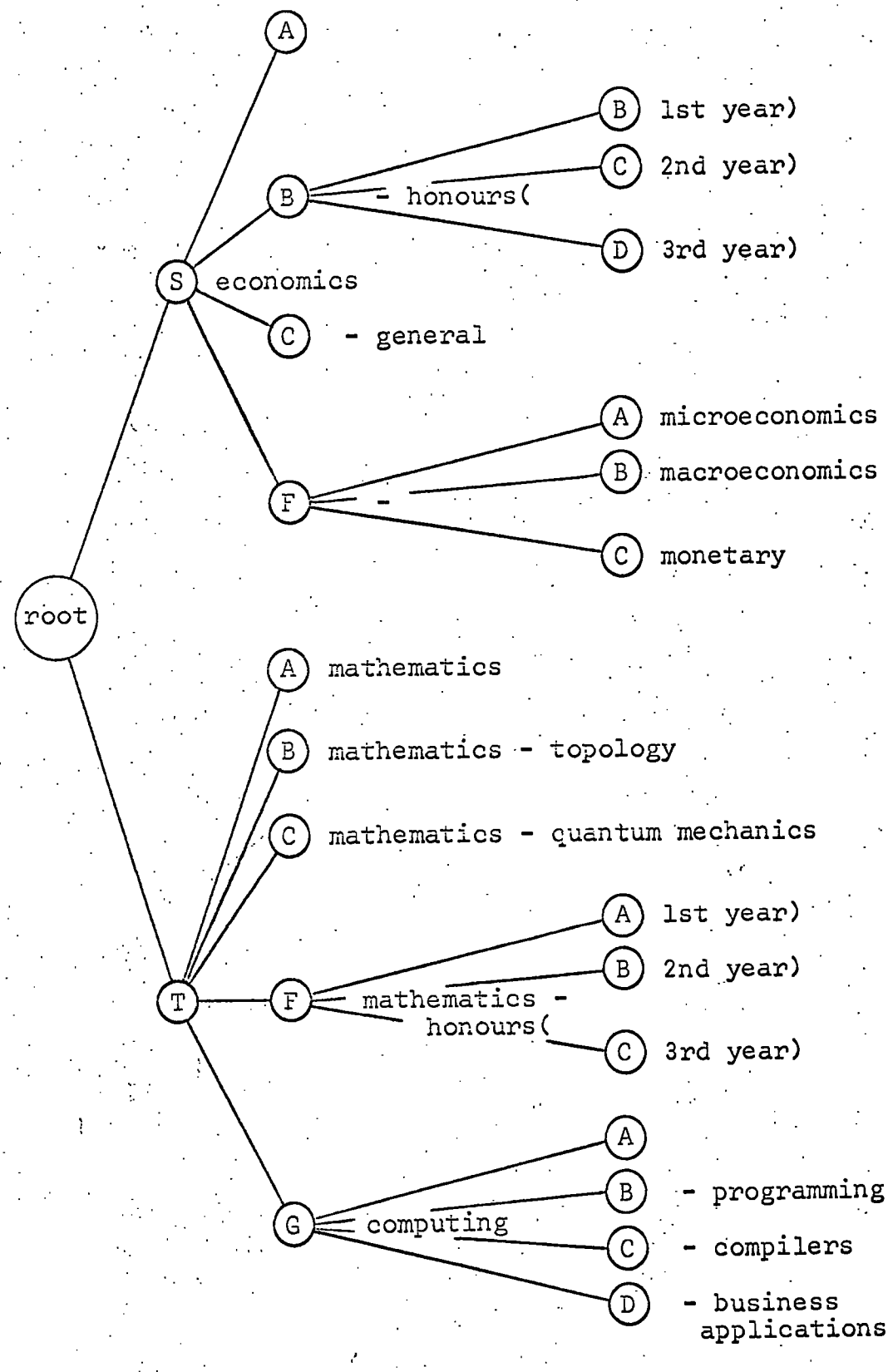
In this half of the tree, there is only one code beginning with SA and similarly with SC, so the nodes labelled A and C are end-points. From the other nodes, we draw another level of nodes corresponding to the third and final letter of the codes. For example:



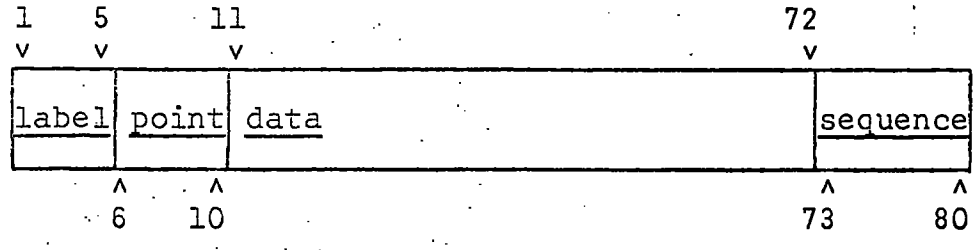
Now we attached the course names to the end-points of the complete tree.



To get the final form of the tree, we move text to the left as far as possible. The rule is: "if all the nodes connected to the right of a particular node, N, have attached to them text starting with a common string of characters, then move that common part to the left one node - to node N".



We can now prepare a card file from the code translation tree. The cards have the following format:



label is not used on every card. If it is present it is a whole number punched anywhere within card columns 1 to 5 inclusive and the number must not be split by spaces.

point does not occur on all cards. It is syntactically the same as label but is punched between columns 6 to 10 inclusive.

data is a string of characters starting in column 11. It is explained below.

sequence is the (optional) card sequence number. It can be completely or partially numeric.

e.g. 00000100
PGC00350

Each node in the tree has a card in the file (we can sometimes economize when sub-trees are very similar). The card corresponding to the root node occupies a specific position in the file; the root of the course code tree, for example, is the 5th card. Cards corresponding to all the nodes connected immediately to the right of any single node must be consecutive in the file.

The cards thus fall into groups, every member of a group having the same "parent" node. The groups can be inserted into the card file in any arrangement. The first card of a group must have a label which must be distinct from every other label used in the entire file. The user may choose his label's from the positive whole numbers less than 100,000 and it does not matter in which order the label's occur in the card file.

If a node is an end-point in the tree (i.e. if it has no nodes connected to the right of it), then the point field of the card is blank and the data field contains the text which is attached to the node.

If a node is not an end-point, then the point field contains the label of the group of cards representing the nodes on its right and the data field is constructed as follows:

(i) Starting in column 11, the text attached to the node,

(ii) Immediately after the text (in column 11 if there is no text) the character *,

(iii) Starting in the column after the asterisk, in consecutive columns and terminating in or before card column 65, the code letters of the nodes connected immediately to the right in the order in which they occur in the card group.

The cards for our sample code tree follow:

```
label point data                                          sequence

          column 11                                       column 73
          v                                               v
        10*ST                                             00000050
                  .                                          .
                  .                                          .
                  .                                          .

    10    20ECONOMICS*ABCF                                00000230
          30*ABCFG                                        00000240
    20                                                    00000250
          21 - HONOURS(*BCD                               00000260
             - GENERAL                                    00000270
          22 - *ABC                                       00000280
    30      MATHEMATICS                                   00000290
            MATHEMATICS - TOPOLOGY                        00000300
            MATHEMATICS - QUANTUM MECHANICS               00000310
          21MATHEMATICS - HONOURS(*ABC                    00000320
          31COMPUTING*ABCD                                00000330
    21      1ST YEAR)                                     00000340
            2ND YEAR)                                     00000350
            3RD YEAR)                                     00000360
    22      MICROECONOMICS                                00000370
            MACROECONOMICS                                00000380
            MONETARY                                      00000390
    31                                                    00000400
            PROGRAMMING                                   00000410
            COMPILERS                                     00000420
            BUSINESS APPLICATIONS                         00000430
```

To illustrate how the computer uses this file to decode an element, let us decode course SBD.

(i) Search the letters after the * on the root card (00000050) for the 1st letter of the code - S. It is the 1st letter on the card, so we move on to the 1st card in the group labelled 10 (card 00000230).

(ii) The text before the * is the first part of the translation:

ECONOMICS

Search the letters after the * for the 2nd letter of the code - B. It is the 2nd in the list, so we go to the 2nd card in the group labelled 20 (i.e. to card 00000260).

(iii) Add the text before the * to what we already have:

ECONOMICS - HONOURS(

Search the letters after the * for the 3rd letter of the code - D. It is the 3rd letter in the list on the card, so we go to the 3rd card in the group labelled 21 (i.e. to card 00000360).

(iv) Add the text on the card to produce:

ECONOMICS - HONOURS(3RD YEAR)

There is no * so we have completed the translation.

Notes

(i) The cards 00000340, 00000350 and 00000360 form a shared group.

(ii) The economics course codes are allocated more economically than the mathematics and computing codes. It would have been better to start the computing codes with a letter other than T. In general, the more text that can be moved to the left in the tree, the better, i.e. a hierarchical notation, although not essential, is preferable.

(iii) A similar, but usually degenerate, translation tree is required for the agent codes (#200) which are also three-letter codes.

One-Character Codes

Decoding operates in essentially the same way for one-character codes but is much more like a straightforward search.

Example

The code list for agent reports (#203) might be this:

A expected Jan.-Mar.
B expected Apr.-June
C expected July-Sept.
D expected Oct.-Dec.
E new edition in preparation - no date
R reprinting/binding - no date
N not published
O out of print

The cards required for the code translation file are:

```
                column 11                                    column 73
                v                                            v
 1000*ABCDERNO                                               00000030
                  .                                            .
                  .                                            .
                  .                                            .
1000              EXPECTED JAN.-MAR.                         00002330
                  EXPECTED APR.-JUNE                         00002340
                  EXPECTED JULY-SEPT.                        00002350
                  EXPECTED OCT.-DEC.                         00002360
                  NEW EDITION IN PREPARATION - NO DATE       00002370
                  REPRINTING/BINDING - NO DATE               00002380
                  NOT PUBLISHED                              00002390
                  OUT OF PRINT                               00002400
```

Example

If we do not wish to use the decoding facility on, say, the first character of the item number, we must nevertheless include a root card (which is blank in the three fields label, point and data:

```
                                                             column 73
                                                             v
                                                             00000010
```

Assembling a Code Translation Card File

There are five code trees in the file and the root cards must come first as follows:

Card 1 - root card for #100 (first letter) codes
Card 2 - root card for #200 codes
Card 3 - root card for #203 codes
Card 4 - root card for #300 codes
Card 5 - root card for #401-#499 codes

Thereafter, the groups of cards (from all the trees) occur in any order. Special care should be taken over labels.

No two cards in the entire file may have the same label field and every point field in the file must also be present as a label field.

Note

It is possible to write a label on a card other than the first in a group. If it is referred to on another card (in the point field), then a part of the group starting at that label is being treated as a group (similar to a general table in a book classification scheme) in a different part of the tree.

8.2 *STORING A CODE TRANSLATION FILE*

The card file described in the previous section is not immediately suitable for use by program PRINT. (A program written to decode using the card file would run very inefficiently.) The program called CODEIN converts the card file into the required form.

1. Command

label CODEIN cardfile ;

label is optional and is any name by which the command can be referred.

CODEIN is the name of the program which converts code translation data from its card form in cardfile to an internal form suitable for decoding operations.

cardfile is an input card file name.

2. Function and Notes

The file cardfile contains information necessary for decoding coded elements and should be prepared according to the scheme described in section 8.1. CODEIN reads the card file called cardfile, performs certain checks upon it and if it is error-free, writes an equivalent internal form of it into the file called SYSCODE. The program produces a listing of file cardfile and prints descriptive messages if any errors or suspected errors are detected. Possible errors fall into two categories:

(i) Format and label errors in cardfile, and

(ii) File definition errors.

There is a limit to the number of labels and label references that can be managed by CODEIN. We express it

in terms of the card fields label and point defined in section 8.1. Let L be the number of label's and P be the number of point's used in cardfile. Then the restriction is

$$32xL + 8xP < 16,000$$

Typically, P is approximately $1\frac{1}{4}$ times L and the number of label's, L, would then be restricted to about 380, which should be sufficient for about 10 times that number of codes.

The program CODEIN uses a work file called WORK1.

3. Data Definition Cards

Job control cards are required to define the data-sets associated with cardfile, SYSCODE and WORK1.

(i) cardfile is a card file, usually on punched cards submitted with the job.

(ii) WORK1 is a normal work file, which has the same organization as an internal bibliographic file as far as the operating system is concerned (although CODEIN does not use it in the same way). The space requirement depends on the number of cards in cardfile, C. It is, in tracks, the nearest whole number above the value of C/92. The catalogued procedure DLFPMCLG provides a suitable definition for WORK1 with a maximum capacity corresponding to C=36,800, which is far in excess of likely requirement.

(iii) SYSCODE is a file with a special organization. It can be new or extant. If it is associated with an existing data-set, the previous contents are overwritten. The space requirement depends on the number of cards in cardfile, C. Let t be the nearest whole number above C/43. Request

SPACE=(TRK,t)

The file must be stored on a disk volume (or other direct access device) and not on magnetic tape. The DCB parameter must be used in the DD statement for a new data-set as follows:

DCB=(RECFM=F,LRECL=66,DSORG=DA)

The catalogued procedure DLFPMCLG has the following definition of SYSCODE, which is designed for its use by PRINT:

```
//SYSCODE DD DSN=DUL01LCO,UNIT=2314,VOL=SER=UNE040,
//       DISP=SHR,DCB=(RECFM=F,LRECL=66,DSORG=DA)
```

Note that the DCB parameter is provided, but it will be necessary to override some of the other information when using CODEIN. Parameters can be overridden individually using a card beginning:

```
//G.SYSCODE DD
```

placed before all the other G-step DD statements in the job.

If the data-set is new, we must code DISP=(NEW,KEEP) and give a space parameter,

E.g. `//G.SYSCODE DD DISP=(NEW,KEEP),SPACE=(TRK,8)`

If the data-set is extant, we must code DISP=OLD (because the job will change it and it cannot be shared).

E.g. `//G.SYSCODE DD DISP=OLD`

The user may have more than one code translation file. He will need to change either the data-set name or the volume or both if he wishes to use one not defined in the catalogued procedure.

E.g. `//G.SYSCODE DD DSN=DUL02ABC,DISP=OLD`

Note that the corresponding change for the benefit of program PRINT, which merely reads the file, is:

```
//G.SYSCODE DD DSN=DUL02ABC
```

4. Computer Time

CODEIN requires 1 second of central processor time for every 94 cards in cardfile or, expressed another way,

CPU time estimate = 0.0107 x number of cards in cardfile.

5. Completion Codes

(i) Completion code 4 if there is a suspected error in cardfile which the user should be warned about. SYSCODE will be written.

(ii) Completion code 8 if there are errors in cardfile or if any of the files are not properly defined. SYSCODE will not be successfully written.

(iii) Otherwise, the completion code will be set to 0.

8.3 *PRINTING AN INDEX OF CODES*

There is a program in the LFP System called COIND which prints an index of the course codes (#401) used in a particular file with their translations.

1. Command

label COIND intfile ;

label is optional and is any name by which the command can be referred.

COIND is the name of the program which produces an index of the course codes occurring in file intfile.

intfile is an input internal file name. The file is assumed to be in one of the course code orders.

2. Function and Notes

COIND reads through file intfile extracting all the different course codes (#401) used in the file (which is assumed to be sorted using one of the sequencing routines SEQ467, SEQ476 or SEQ486). The program decodes the elements using file SYSCODE and prints codes and translations side by side in two columns. The list of courses is printed twice; one list is in alphabetical order of code, and the other is in alphabetical order of course name.

The file SYSCODE is of the type produced by program CODEIN (see section 8.2) and is used in the same way as by PRINT for decoding elements.

It is operationally efficient to run COIND when catalogues or lists in course order are being produced, because a sorted file will already be available. For example, the following command might be placed after the SORT command in program CCAT of section 7.5:

```
COIND COURSE ;
```

3. Data Definition Cards

Job control cards are required to define data-sets for the files intfile and SYSCODE.

(i) intfile is an input internal file which has, of course, been previously created.

(ii) SYSCODE must be defined on a special data-set as created by a previous run of CODEIN (see section 8.2). The catalogued procedure provides a definition for SYSCODE which is suitable so long as the data-set name and volume are correct.

4. Computer Time

The central processor time required by COIND should not exceed

$$0.002xI + 0.0074xC \text{ seconds},$$

where I is the number of items and C is the number of different #401 codes in intfile.

If, for example, we have employed 500 codes in a file of 10,000 items, it will take no more than

$$0.002x10{,}000+0.0074x500 = 23.7 \text{ seconds}$$

of CPU time to execute COIND.

5. Completion Codes

(i) Completion code 4 if there are no codes (#401) in intfile.

(ii) Completion code 8 if either intfile or SYSCODE is not properly defined.

(iii) Otherwise, the completion code will be 0.

9

FILE UTILITY PROGRAMS

In this final chapter, we describe the functions of the five remaining programs in the LFP System. Two of them are designed to work on bibliographic files and the other three do not require their files to have any particular type of content.

(i) FPUNCH reads a bibliographic file in internal format and produces the externally formatted equivalent in a card file.

(ii) BATCH reads an external bibliographic file augmented by certain instructions for generating extra items and produces a new external (card) file, which is suitable for input to program FINPUT.

(iii) IMAGE copies a card file. It can be used to store a card file, such as a control file for PRINT or even a program of commands, on a disk volume. The cards can be numbered by IMAGE or numbers can be removed. The contents of the cards are immaterial.

(iv) CDLIST lists a card file on the printer.

(v) RUNOFF makes copies of printout produced by other jobs. We can store a printout on a disk instead of printing it and then use RUNOFF to copy it to the printer as many times as required.

9.1 *FILE CONVERSION (INTERNAL TO EXTERNAL FORMAT)*

1. Command

label FPUNCH intfile extfile ;

label is optional and is any name by which the command can be referred.

FPUNCH is the name of the program which reads an internal file (intfile), converts its items to the external format and writes them into the card file extfile.

intfile is the name of an input internal file.

extfile is the name of an output card file which will contain items in external format.

2. Function and Notes

FPUNCH reads the internal file intfile item by item and writes the items, externally formatted, into card file extfile. The output card file can be on a disk volume or a magnetic tape or punched by the computer on cards. Each external item starts in column 1 of a new card (or 80-byte record) and the last eight columns (73-80) are automatically filled with an 8-digit card number (starting at 00000010 and incrementing by 10). The program will use as many cards as are necessary to complete the item.

As regards the distinction between the normal and updating formats, the equivalence between the internal and external files is exact. We illustrate this with an example. The original external item as read by FINPUT is:

```
#100 S0731£ #102 B£ #300 H£ #401 MAX£ #500 1962£
   #601 IVERSON K.E.£ #701 A PROGRAMMING LANGUAGE£ #900 WILEY£ *
```

If the internal item produced by FINPUT were subjected to the treatment of program FPUNCH, the external item would come out unchanged. If, however, the internal item, which is in updating format, were first converted by UPDATE into normal format, then FPUNCH would produce the item:

```
#100 S0731£ #102 B£ #200 £ #201 £ #202 £ #203 £ #300 H£
#301 £ #302 £ #401 MAX£ #500 1962£ #601 IVERSON K.E.£
#701 A PROGRAMMING LANGUAGE£ #900 WILEY£ *
```

Note that there is a difference between the representation of the ranges of elements #401 to #499, #601 to #699, #701 to #799, #801 to #899 and all the other elements in the "blank" cases. The former are "absent" (for economy of storage) and the latter are null.

The file names intfile and extfile must be different because they represent different types of file.

3. Data Definition Cards

Job control cards are required to define the data-sets associated with intfile and extfile.

(i) intfile is an input internal file which has been created previously.

(ii) extfile is an output card file. The data-set can be an existing one which previously held a card file and will now be overwritten, or it can be a new one or the card punch. The card punch is used by including a DD card as:

```
//G.CARDS DD SYSOUT=B
```

The space requirement for storing a card file on a 2314 disk volume is 1 track for every 70 cards in the file. The user must therefore estimate the number of cards (80-byte records) which are to be produced and that will depend upon how he has used the elements within the items. In Durham University, an item as formatted by FPUNCH typically requires 3 cards. We can discover exactly how many cards will be produced by executing the command:

```
FPUNCH LBK DUMMY;
```

The output card file will be lost (DUMMY) and therefore requires no space on a disk, but the program informs us how many cards it has formatted.

4. Computer Time

The following formula will give an estimate of the central processor time required in terms of the number of items in the file (I) and the number of cards or 80-byte records produced (C).

CPU time = 0.0041xI + 0.0126xC seconds

If, for example, the file contains 500 items and there are 3 cards per item in the externally formatted file, then

I = 500 and C = 1,500,

so the CPU time is estimated to be

0.0041 x 500 + 0.0126 x 1500 = 20.95 seconds.

5. Completion Codes

(i) Completion code 8 if the files are not properly defined.

(ii) Completion code 12 if an item in intfile cannot be read. This is not usually the fault of the user.

(iii) Otherwise the completion code will be 0.

9.2 *AUGMENTED EXTERNAL FILES*

Section 3.4 contains the rules for constructing items for an external file. We now recapitulate the syntax of a file in external format.

(i) An element is punched:

tag text £

tag is one of the usual element numbers (see figure 3.2).

E.g. #302

Spaces are allowed between the # and the number, but not within the number.

text is the value of the element. Any sequence of characters not including #, £ or * is allowed. Spaces at the beginning and end of the text will be ignored.

£ is the terminating character.

(ii) An item consists of one or more elements, optionally separated by spaces. The last element is followed by a *. An item may contain no two elements with the same tag and it must contain an item number (element #100). The elements may appear in any order in the item.

(iii) An item is called a deletion item if, in the syntactic position of an element, it contains either

DELETE
or DELETE £

(iv) An external file is a sequence of one or more items, as defined above, optionally with spaces between them.

This is the form of file read by FINPUT and written by FPUNCH. We shall define a type of card file called an augmented external file by adding to the above syntax, and it will be suitable for input to program BATCH (see section 9.3) but not to program FINPUT.

An augmented external file consists of the following units arranged in any sequence:

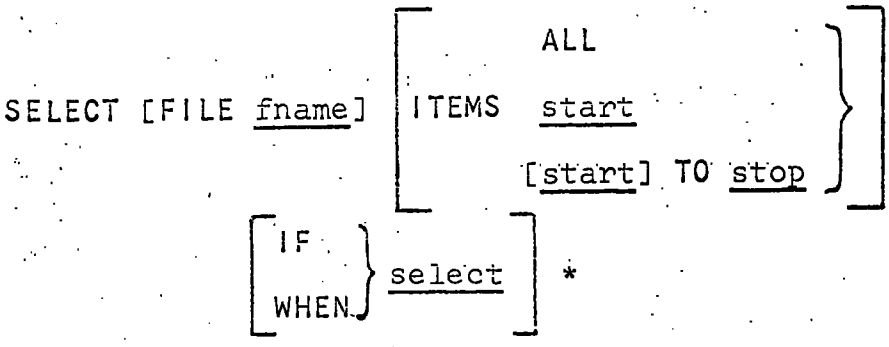
(i) Normal items as occur in an external file.

(ii) Selection statements, which represent groups of primitive items, consisting of item numbers only.

(iii) "Batch" items, which specify elements common to a number of items in the file.

The Selection Statement

The usual syntax notation is used - brackets ([ ]) enclose optional clauses and alternatives are stacked one above the other with a brace (}) on their right. The prototype selection statement is:



fname is the name of an internal file.

start is either an item number or the word FIRST.

stop is either an item number (alphabetically/numerically greater than start if that is specified as an item number) or the word LAST.

select is a selection specification with the syntax described in section 4.4. select should be enclosed in quotes if it contains any of the characters: space, comma, #, £, *.

There are three optional clauses in the statement called the "file" clause, the "item" clause and the "if" clause.

If the file clause is omitted, fname is assumed to be the same as the fname given or assumed in the previous selection statement in the file. Note that the first selection statement in the augmented external file must have a file clause.

If the item clause is omitted from the statement, the default clause

ITEMS ALL

is assumed.

In the absence of an explicit if clause,

IF ' '

is assumed.

Examples

```
SELECT FILE LBK IF '#300=A' *

SELECT ITEMS D1200 TO D1299 *

SELECT FILE SBK ITEMS D2000 IF '#102=BJ' *
```

Function of the Selection Statement

The selection statement stands for a list of items, each consisting solely of an item number:

#100 itemno £ *

There is one such item corresponding to each item in the internal file fname which both (a) has an item number in the range specified in the item clause and (b) satisfies the selection criterion in the if clause. itemno is the same as the #100 element of the corresponding item in fname. The absence of the item or if clause implies its irrelevance in choosing items for inclusion in the list represented by the selection statement. (That is what is meant by the default clauses, of course.) We must now define how the range of item numbers is obtained from the item clause.

Firstly, file fname must be in item number (#100) order. ITEMS ALL and ITEMS FIRST TO LAST and clauses which imply one of these mean that the range is from the first item number in fname to the last.

ITEMS start TO stop. The range is all the item numbers in fname from start to stop, inclusive of start and stop if they are, respectively, in fname. (It is not an error if either start or stop is not the number of any item in fname.)

Batch Items

A batch item is syntactically like a normal item but the #100 element is replaced by the word

BATCH

Examples

```
BATCH #300 A£ #200 COM£ *

BATCH DELETE *
```

No batch item should have a #100 element.

Function of Batch Items

The whole item, apart from the word BATCH, is to be appended to every normal item (including those implied by selection statements) after this batch item and before the next (if there is one).

The batch item which simply nullifies the effect of the previous one without itself having any effect is:

```
BATCH *
```

Examples of Augmented External Files

(i) Assume that the file KBK contains items numbered consecutively starting with D0001. We show first an annotated augmented external file and then the normal external file which it represents.

The augmented file:

```
#100 D0317£ #300 H£ *              - normal item
BATCH #102 J£ *                    - application of batch
#100 D0513£ *                                        item
SELECT FILE KBK ITEMS D0732 TO D0735 *
#100 D0915£ #302 2.50£ *
BATCH #102 B£ *                    - application of batch
#100 D0916£ *                                        item
SELECT ITEMS D0918 TO D0921 *
```

The normal file:

```
#100 D0317£ #300 H£ *
#100 D0513£ #102 J£ *
#100 D0732£ #102 J£ *
#100 D0733£ #102 J£ *
#100 D0734£ #102 J£ *
#100 D0735£ #102 J£ *
#100 D0915£ #302 2.50£ #102 J£ *
#100 D0916£ #102 B£ *
#100 D0918£ #102 B£ *
#100 D0919£ #102 B£ *
#100 D0920£ #102 B£ *
#100 D0921£ #102 B£ *
```

(ii) Suppose that the status (#300) H means "withdrawn". The following augmented external file can be used to generate an updating file to remove the records of withdrawn material from the file SBK:

```
BATCH DELETE *
SELECT FILE SBK IF '#300=H' *
```

9.3 *THE BATCH PROGRAM*

The LFP System program called BATCH will read a file in augmented external format (see previous section) and expand it into the normal external file which it represents - a file suitable for input to the program FINPUT (section 4.1).

1. Command

label BATCH augfile column switch extfile ;

label is optional and is any name by which the command can be referred.

BATCH is the name of the program which reads a card file (augfile) in augmented external format and writes the file (extfile) in normal external format.

augfile is the name of an input card file containing an augmented external file.

column is a number not exceeding 80. It specifies the last column from which data is to be taken (e.g. 80 if the whole card in augfile is read, 72 if columns 73-80 are ignored as in the case of numbered cards).

switch is either ON, if a printed copy of the card file augfile is required, or OFF if the printout is to be suppressed.

extfile is the name of an output card file which will contain items in external format.

2. Function and Notes

Program BATCH reads the card file augfile containing augmented external items and applies the batch items and selection statements to produce a file in normal external format, which it writes into the card file extfile. The syntax and meaning of batch items and selection statements are given in section 9.2. The items are written to extfile in the same format as program FPUNCH uses. Each item starts in column 1 of a new card (or 80-byte record) and columns 73 to 80 inclusive are used for a card number (starting at 00000010 and incrementing by 10).

Items in augfile do not receive the full checking that FINPUT gives them, but the syntax is checked and messages are printed to indicate errors and warn of possible errors. If an error is detected in a normal item, that item is skipped and processing continues with the next one. If, however, an error is found in a batch item, the run is terminated immediately because such errors would propagate through the file.

The file names augfile and extfile must be different. The normal way to define them is to make augfile a deck of cards in the job and extfile a temporary file on a disk volume which is read by program FINPUT straightaway. Note that if augfile contains no batch items or selection statements (i.e. it is an ordinary external file), the items in extfile will be identical to those in augfile.

3. Data Definition Cards

Job control cards are required to define the data-sets associated with augfile, extfile and any internal files mentioned in the file clauses of selection statements in augfile.

(i) augfile is an input card file which can be on punched cards submitted with the job or in a previously created data-set on a disk volume or magnetic tape.

(ii) extfile is an output card file. The data-set can be a previously created one, in which case it is overwritten, or it can be a new one, or it can be punched onto cards. Space must be allocated if it is a disk data-set (70 cards per track).

(iii) The internal files from which item numbers are extracted must be data-sets created previous to the execution of the BATCH command.

4. Computer Time

The central processor time required by BATCH can be estimated from the following formula:

$$0.04 \times C_I + 0.0078 \times C_o + 0.0014 \times I \text{ seconds}$$

where C_I = number of cards (or 80-byte records) read from augfile

C_o = number of cards (or 80-byte records) written into extfile

I = number of items read from internal files referred to in SELECT's

5. Completion Codes

(i) Completion code 4 is set in cases of syntax error when either corrective action can be taken or a normal item can be ignored.

(ii) Completion code 8 is set if either card file is not properly defined, in which case the execution is terminated, or a batch item is found to be in error (execution is terminated), or various syntax and file definition errors occur in a selection statement, in which case the statement is ignored.

(iii) Completion code 12 is set if there is a format error in an internal file mentioned in a selection statement. This is not usually the fault of the user. Processing proceeds with the next item after the selection statement, but the contents of extfile will be most unreliable.

(iv) Otherwise, the completion code is set to 0.

6. Example - An Ordering Program

The LFP System has no facilities for accounting and therefore it is not currently feasible to use it for full scale ordering. However, orders can be printed automatically to be sent to the agents and this example shows how it is done. We assume that these two status codes (#300) are used in the main file LBK:

A meaning "to be ordered"

C meaning "on order"

LBK is assumed to be in item number (#100) order. We require a program which will print an order for each item in LBK with the status A and then change the status to C. We do not wish to make out items by hand for the updating process.

We shall have to make estimates based on the size of LBK and the number of items to be ordered. Let file LBK contain 3,000 items. Estimates will allow for up to 250 items with status A.

The Program

```
ORDER PROGRAM;
      FCOPY LBK '#300=A' TEMP /* TEMP CONTAINS THE
            ITEMS TO BE ORDERED */;
      BATCH SYSIN 80 ON AMEND /* SYSIN REFERS TO TEMP,
            WHICH IS STILL IN ITEM NUMBER ORDER */;
      SORT TEMP TEMP SEQ200 /* AGENT/PUBLISHER ORDER */;
  OUT PRINT CONTROL 72;
      IF OUT>4;
      GOTO EXIT; /* SKIP UPDATE IF PRINT NO GOOD */
      FINPUT AMEND 72 /* RECORDS ARE NUMBERED */ ON TEMP
            /* CAN USE TEMP AGAIN NOW */,' ',' ',C,' ';
      UPDATE LBK TEMP LBK OFF;
 EXIT END;
```

We define file SYSIN as follows:

```
//G.SYSIN DD *
   BATCH #300 C£ #201 7/12/70£ *
   SELECT FILE TEMP *
/*
```

TEMP is a temporary file which will contain at most 250 full items, so allocate it SPACE=(TRK,(5,1)).

AMEND is a temporary file to take at most 250 cards (one for each short amendment item); we allocate it SPACE=(TRK(4,1)).

The other files which require definition are LBK, WORK1 (for SORT and UPDATE), WORK2, WORK3 and WORK4 (for SORT), CONTROL (defined below) and SYSCODE.

```
//G.CONTROL DD *
  LIST FILE TEMP; /*PRINT ORDERS*/
  SPACE 5;
  PAGE 6,#200 DECODED; /*AGENT*/
  H 10,'DURHAM UNIVERSITY LIBRARY';
  12,(#100,19,#TODAY);
  17,#601,CONT IN 19,STOP IN 66; /*AUTHOR*/
  SKIP;
  21,#701,CONT IN 23,STOP IN 66; /*TITLE*/
  21,(#900,2,#500),CONT IN 23,STOP IN 66; /*PUBLISHER,DATE*/
  72,#302; /*PRICE*/
  END;
/*
```

The reader may wish to work out what the orders will look like, and how many lines of output to expect for 250 orders.

An estimate for the CPU time required for 250 orders can be made:

```
CPU time =  FCOPY CPU time  + BATCH CPU time
           (      6         +     2.4       )

         + SORT CPU time    + PRINT CPU time
          (0.005x250x8      +       5        )

         + FINPUT CPU time + UPDATE CPU time
          (     15         + 0.5+0.001x3000+0.05x250)

        = (approx.) 55 seconds.
```

The job-class will certainly have to be C.

9.4 *COPYING CARD FILES*

1. Command

label IMAGE infile column outfile switch ;

label is optional and is any name by which the command can be referred.

IMAGE is the name of the LFP System program which copies the data from one card file (infile) to another (outfile).

infile is an input card file name.

column is a number not exceeding 80. Characters are copied from columns 1 to column of file infile.

outfile is an output card file name.

switch is either ON or OFF. If it is ON, columns 73 to 80 inclusive are used for card sequence numbers and the data from infile is placed in columns 1 to 72 of the cards in outfile. If switch is OFF, all 80 columns of the cards in outfile are used. This parameter can be used independently of column.

2. Function and Notes

Program IMAGE copies the characters from the field, determined by column, of the cards (or 80-byte records) in infile to the cards in outfile, using either 80 or 72 card columns. All the characters in columns 1 to column of the input cards (or records) will be written into the output records and there is not necessarily a one to one correspondence of cards in the two files.

The file names infile and outfile must be different.

The effects of four commonly used combinations of parameters are given below.

(i) IMAGE INPUT 80 OUTPUT OFF;

This command produces in OUTPUT an exact copy of the cards in INPUT.

(ii) IMAGE INPUT 80 OUTPUT ON;

All the characters in INPUT are written in groups of 72 to OUTPUT and the output cards are numbered. There will be 11% more cards in OUTPUT than in INPUT.

(iii) IMAGE INPUT 72 OUTPUT OFF;

This is the reverse process of the previous example. The last eight columns of the cards in INPUT are eliminated in the copy. There will be 10% fewer cards in OUTPUT than in INPUT.

(iv) IMAGE INPUT 72 OUTPUT ON;

File OUTPUT will contain numbered cards containing

exact copies of columns 1 to 72 of the cards in INPUT. We can use this command to number cards (or records) when we know that columns 73 to 80 are free.

The IMAGE program can be used to manipulate external files - to store them on disk or to number them - and it provides a simple way to store programs of commands and print-control statements on a disk so that reference can be made to them by other jobs.

3. Data Definition Cards

Job control cards are required to define the data-sets associated with files infile and outfile.

(i) infile is an input card file and should either be held in a previously created data-set on a disk volume or magnetic tape or be submitted with the job on cards.

(ii) outfile is an output card file. This can be punched onto real cards or be stored in a data-set on a disk volume, for instance. The space requirement is, as usual, 1 track for every 70 card records. The data-set can be either a new one or an extant one in which case the previous contents are overwritten.

4. Computer Time

To obtain an estimate of the CPU time required by IMAGE,

(i) allow 1 second for every 1,000 cards in infile,

(ii) if the number of cards in outfile will differ from that in infile, increase the time by 10%.

(iii) if switch is ON, i.e. the records in outfile are to be numbered, double the time allowance.

E.g. If file INPUT contains 10,000 card records, the command

```
IMAGE INPUT 80 OUTPUT ON;
```

should be allowed

(10 + 10% of 10) x 2 seconds

i.e. 22 seconds

5. Completion Codes

(i) Completion code 8 is set if either file is not properly defined. No copying will be done.

(ii) Otherwise, the completion code will be 0.

6. Example - Using Stored Programs

We give two jobs in this example. The first uses IMAGE to store a program of commands and a print-control file, and the second uses the two stored card files. At the end of section 9.3 the major constituents of a job to print orders were given and it is clearly a rather complicated job.

The following job (DUL01E6A) stores the program called ORDER and the print-control statements in two separate datasets on a disk volume. Comments have been removed for compactness. The stored versions are numbered.

```
//DUL01E6A JOB (0003,C105),LIBRARY
//       EXEC DLFPMCLG
//M.SYSIN DD *
 STORE  PROGRAM;
        IMAGE IN1 72 PROGF ON /*STORE PROGRAM*/;
        IMAGE IN2 72 PRINTF ON /*STORE PRINT-CONTROL
                                    STATEMENTS*/;
        END;
/*
//G.PROGF DD DSN=DUL010RP,UNIT=2314,VOL=SER=UNE040,
//       DISP=(NEW,KEEP),SPACE=(TRK,1)
//G.PRINTF DD DSN=DUL010RQ,UNIT=2314,VOL=SER=UNE040,
//       DISP=(NEW,KEEP),SPACE=(TRK,1)
//G.IN1 DD *
 ORDER  PROG;
        FCOPY LBK '#300=A' TEMP;
        BATCH SYSIN 80 ON AMEND;
        SORT TEMP TEMP SEQ200;
   OUT  PRINT CONTROL 72;
        IF OUT>4;
        GOTO EXIT;
        FINPUT AMEND 72 ON TEMP,' ',' ',C,' ';
        UPDATE LBK TEMP LBK OFF;
  EXIT  END;
/*
//G.IN2 DD *
  LIST FILE TEMP; SPACE 5; P 6,#200 DECODED;
  H 10,'DURHAM UNIVERSITY LIBRARY';
  12,(#100,19,#TODAY);
  17,#601,CONT IN 19,STOP IN 66;
  S; 21,#701,CONT IN 23, STOP IN 66;
  21,(#900,2,#500),CONT IN 23,STOP IN 66; 72,#302;
  END;
/*
//
```

Now we can use the files in our jobs to produce orders.

```
//DUL01E6B JOB (0012,C105,,2),LIBRARY,CLASS=C
//     EXEC DLFPMCLG,TIME.G=(3,0)
//M.SYSIN DD DSN=DUL010RP,UNIT=2314,VOL=SER=UNE040,DISP=SHR
//G.WORK2 DD UNIT=2314,VOL=SER=UNE020,SPACE=(TRK,(5,1))
//G.WORK3 DD UNIT=2314,VOL=SER=UNE030,SPACE=(TRK,(5,1))
//G.WORK4 DD UNIT=2314,VOL=SER=UNE040,SPACE=(TRK,(5,1))
//G.TEMP  DD UNIT=2314,VOL=SER=UNE999,SPACE=(TRK,(5,1))
//G.AMEND DD UNIT=2314,VOL=SER=UNE999,SPACE=(TRK,(4,1))
//G.LBK DD DSN=DUL01LBK,UNIT=2314,VOL=SER=UNE040,DISP=OLD
//G.CONTROL DD DSN=DUL010RQ,UNIT=2314,VOL=SER=UNE040,DISP=SHR
//G.SYSIN DD *
    BATCH #300 C£ #201 7/12/70£ *
    SELECT FILE TEMP *
/*
//
```

Note

Data-sets DUL010RP and DUL010RQ contain 10 and 7 card records respectively. They have each been allocated the smallest possible space - 1 track - and even that is far too large, since it has a capacity of 70 cards. If it is required to store many very small card files (of the order of 10 cards per file) a "library" data-set can be created on a disk volume with the partitioned organization which enables files to occupy less than a track and yet not waste the remainder. IMAGE can be used to add new members to this library.

9.5 *PRINTING CARD FILES*

1. Command

label CDLIST cardfile

label is optional and is any name by which the command can be referred.

CDLIST is the name of the program which prints out the contents of the card file cardfile.

cardfile is an input card file name.

2. Function

CDLIST reads the cards (or 80-byte records) in the card file cardfile and prints out their contents, one card per line.

3. Data Definition Card

A job control card is required for the input card file cardfile. It is either a previously created data-set on a disk volume or magnetic tape or a deck of cards contained in the job.

4. Computer Time

The central processor time required by CDLIST is approximately 2 seconds for every 1,000 cards (records) in cardfile.

5. Completion Codes

(i) Completion code 4 is never set by CDLIST.

(ii) Completion code 8 is set if cardfile is not properly defined. No list will be produced.

(iii) Otherwise, the completion code will be 0.

9.6 *STORING PRINTOUTS*

This section is not, as might be thought from the title, concerned with the storage in the library of the vast piles of paper obtained from the computer's printer over the months. It is concerned with a method of saving processor time in the production of more than one copy of a printout.

All printing that is done by the LFP System programs is achieved by sending line-records to a file called SYSPRINT, which is normally associated with the printer by a DD card in the catalogued procedure DLFPMCLG. Now, instead of printing this file, we can store it on a disk and then, in a subsequent job, run off copies of the file on the printer.

Notes

(i) If we wish to store a printout on a disk volume (or magnetic tape), we must store all the output from the final step of the job (step G). None of it will be printed at the time.

(ii) Each copy of the output produced from a previously stored printer file will be the complete job-step printout of the program that stored it.

We show how to store a printer file through an example.

```
//DUL01E96 JOB (0010,C105),LIBRARY,CLASS=C
//     EXEC DLFPMCLG,TIME.G=(5,0)
//M.SYSIN DD *
```

program of commands (to produce an author catalogue, for example)

```
/*
//G.SYSPRINT DD DSN=DUL01PRT,UNIT=2314,VOL=SER=UNE040,
//         DISP=(NEW,KEEP),SPACE=(TRK,(60,5)),
//         DCB=(RECFM=VBA,LRECL=125,BLKSIZE=1254)
//G.WORK2
```

DD . . .   etcetera

```
//
```

The DD statement beginning //G.SYSPRINT overrides the statement in the catalogued procedure. With the suggested DCB parameter, a track on the disk will hold at least 50 lines (full 120 character records). If, for example, it is known that the average length of the lines will be 90 characters, the track capacity will increase to 65 lines.

The LFP System program RUNOFF will read a printer file (referred to by a name other than SYSPRINT) and copy it to file SYSPRINT as many times as required. It should be remembered that there are other ways of producing multiple copies of printout.

(i) Use printer stationery with carbon paper (see operations staff).

(ii) Request more than one copy of the whole job's output (see operations staff).

(iii) Run the job more than once.

A combination of methods may be advantageous for large printing tasks. If, for example, we have to produce 30 copies of an author catalogue, each 4,000 lines long, we might print the list 10 times using triple forms. 40,000 lines would still be considered a very large printing job on a university machine and the operational staff might prefer that the job be divided into two of 20,000 lines. The method would therefore be to submit three jobs:

(i) Produce formatted author catalogue in a printer file on a disk volume.

(ii) Print 5 copies on triple forms using program RUNOFF.

(iii) Print 5 copies on triple forms using program RUNOFF and delete the stored printer file.

Program RUNOFF

1. Command

label RUNOFF pfile copies ;

label is optional and is any name by which the command can be referred.

RUNOFF is the name of the program which produces copies for the printer of the printout stored in pfile.

pfile is the name of an input file containing properly formatted lines for printing. It must be different from SYSPRINT.

copies is any positive whole number.

2. Function

RUNOFF copies the line-records in pfile to the standard printer file, SYSPRINT, copies times. The beginning and end of each copy are marked START and END.

3. Data Definition Card

A job control statement is required to define file pfile, which should be contained in a previously created data-set on a disk or magnetic tape. The data-set should have originally been written via the file SYSPRINT in a previous job.

4. Computer Time

The central processor time required by RUNOFF is approximately 1 second for every 500 lines printed. Expressed another way, that is

0.002 x number of line records in pfile x number of copies printed

5. Completion Codes

(i) Completion code 4 is never set by program RUNOFF.

(ii) Completion code 8 is set if file pfile is not properly defined.

(iii) Otherwise, the completion code will be 0.

10 COMPUTING TECHNICAL ASPECTS

10.1 PROGRAMMING CONSIDERATIONS

The Library File Processing System was implemented in PL/1 (Programming Language One), which the programmer was able to use with speed. Full listings of the programs and other technical documentation are contained in [125], which accompanies this thesis as supplementary material. Computer programs for library processes typically perform the following types of operation:

(i) Input and Output. Records are read from magnetic tapes, disks and punched cards, and written to tapes, disks and printers, for example. In the majority of applications files are sequential even though direct access storage devices are becoming quite common. In multiprogramming and time-sharing operating systems, direct access facilities are essential even if every user is processing his files sequentially.

(ii) Arithmetic. On the one hand statistical and accounting calculations are required in some applications and on the other hand the data structures which one creates imply the use of address computations.

(iii) String handling. The simplest operations in this category are those of breaking fields out of records when the substring boundaries are obtainable arithmetically (from data in the record itself, for instance), and joining strings together as for output. More complex are the processes of identifying patterns of characters in strings and extracting, replacing or deleting substrings so defined. One often wishes to separate the words in a natural sentence, for instance.

(iv) Interpretation. The user's requirements are generally communicated to the application program in a code which is oriented, in some degree, towards the user, and must be translated before they can "drive" the program. This is largely a matter of manipulating strings, lists, tables and other data structures.

All of these facets are represented in the LFP System programming and there follows a brief discussion of the suitability of the programming language and operating system used (IBM System/360 Operating System). A full, implementation-specific, description of PL/1 is given in

IBM's PL/1 Reference Manual[122] and Programmer's Guide[121] and a summary, highlighting the major features of the language (and glowing with praise for it) is included in Sammet[130]. A user's introduction to 360/OS is available in [117,118].

The data transmission facilities of PL/1 are comprehensive, providing for "record" and "stream" input/output. "Record" statements permit the transference of complete logical records between two levels of storage (core and disk, for example). Statements are very easy to construct and the programmer need not concern himself with the implementation of buffering and blocking. Records can be variable in length and files may be sequential, direct or indexed sequential. Record input/output in PL/1 is quite close to the macros provided in 360/OS for the assembler programmer. "Stream" files as handled by the PL/1 GET and PUT statements are sequential files in which the records are normally regarded as being joined together in a continuous string. Fields whose boundaries do not necessarily match those of the records can be read and written and data can be reformatted and converted. On the whole, the PL/1 input and output repertoire is adequate and useful. It is interesting to note that, in a serials system at Laval University Library programmed predominantly in Assembly language, PL/1 was used for I/O [133]. The weak point for this application is stream input. For the initial input of bibliographic data, stream input is desirable, but not if it is restricted, as in PL/1, either to formatted data or to the retrieval of numerical fields or strings enclosed by quotes. It is therefore necessary to write rather ungainly procedures to separate the words and symbols in the input.

The System/360 Operating System file policy is that they should be accessed in a device-independent manner, i.e. a program can be written without knowing in advance which devices will contain it's files. Each file therefore has two levels of identification, one within the program and one, given when the program is run, to provide the physical description necessary to locate the actual records. 360/OS has an intricate Job Control Language[119], most of which is concerned with the latter aspect of file definition. The range of facilities is very wide and the computer user is assumed to wish for a fine degree of control. The intended user of the LFP System should not be expected to become a computer programmer, and as much as possible of the control and description of files is embedded in the programs. Nevertheless, much of the effort of preparing a job goes into writing the DD statements for the files used, even with the aid of a catalogued procedure (see section 7.5 in Chapter 7 for examples).

The University Library at Durham has not yet requested any statistical or financial calculations to be performed and there are no programs in the system for these types of function. Arithmetic is restricted to some counting and address calculation. PL/1 is quite satisfactory in this area at the language

level, although not efficient in comparison with fairly easily written "low-level" equivalent routines. The "structure" type of variable derived from COBOL is not suitable for representing a record containing several variable length fields and the obvious technique is to use a single long character string from which fields can be retrieved using the PL/1 built-in function SUBSTR. Any substring can be addressed, using the position of its first character and its length; however, the compiler (F-level) rarely generates in-line code for this function, preferring to use a general purpose subroutine. A record format in which numerical control data (addresses and lengths) occur in variable positions can also be awkward to handle in PL/1 unless one is prepared to put up with the processing inefficiency implied by storing the numbers in character form (in decimal) as in the MARC II communications format[36]. Snell[132] gives relevant examples of PL/1 programming. Languages which are effectively equivalent to block diagrams of generalized record structures have been proposed[110,129] and could probably be implemented quite efficiently.

Those who claim that PL/1 has string processing facilities are usually making comparative statements against a background of ALGOL, COBOL and FORTRAN. In reality the language provides little more than the ability to address one or more bytes at a specified location and of specified length, versatility being obtained by calculating the location and length during execution of the program. There is no qualitative difference between programming string operations in PL/1 and in Assembly language (or in FORTRAN, with appropriate abuse of LOGICAL and other data types!). This approach, augmented by the ability to compare strings, was found to be adequate in the LFP System programs in which the most complex operations are those associated with input and output - breaking up strings using various delimiters and the formatting operations of program PRINT. However, the more complex the operation, the more confusing it is to the programmer to have to design his algorithm in terms of the numerical position of the substrings, and the more the algorithm is complicated by the storage structures required to accommodate substitutions, unrestricted by length considerations, within strings. String processing languages like SNOBOL[115] exist for just these situations. The programmer may specify complicated patterns of characters to be searched for, and extracted or replaced in strings. Normal computers with their "matrix" of fixed-length storage cells do not lend themselves naturally to these operations and compilation of source programs in SNOBOL is virtually impossible. Consequently, the language is implemented interpretively (by a "SNOBOL machine" simulation) and one can usually write equivalent Assembler language programs which run ten times as fast. The other major disincentive to using SNOBOL is that string processing is only one aspect of the problem and combination with modules written in another language is not practicable for any routine which must be run with an interpreter. SNOBOL can be useful as a program design tool, but should be abandoned

at the final coding stage. As an example of its suitability for expressing string operations precisely and concisely, we consider the construction of output strings and sort keys from the stored form of subject headings described by Johnson (p.23 in Chapter 2, and ref.88). The stored heading:

ROME-HISTORY-<REPUBLIC, 365-30 B.C.>@Z9734-Z9969@

prints as:

ROME-HISTORY-REPUBLIC, 365-30 B.C.

and files as:

ROME-HISTORY-Z9734-Z9969

Characters between < and > are ignored for filing and those between a pair of @'s are ignored for printing. The characters <, > and @ are not included in either derived string and a stored subject heading may have several "bracketed" substrings. Suppose that the string variable, SUBJECT, contains the stored form of the heading. The SNOBOL4 statement which follows will change it into the print form.

```
LOOP SUBJECT   ('@' ARB '@') | '<' | '>' =        :S(LOOP)
```

This can be read: "Find the first substring from the left hand end of SUBJECT which is either @ followed by any number of characters followed by @, or <, or >, and replace it by nothing (i.e. delete it). If no substring is matched, no deletion takes place and control passes to the next statement. Otherwise, repeat the process". A similar statement can be used to generate the sort key:

```
ROUND SUBJECT   ('<' ARB '>') | '@' =             :S(ROUND)
```

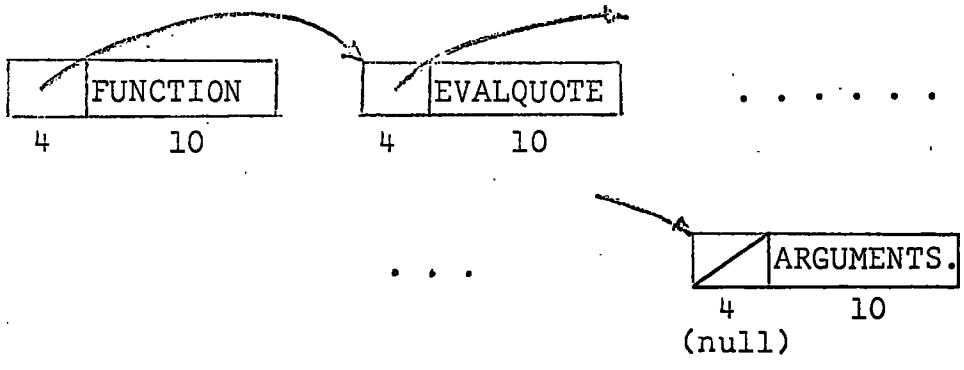
The above SNOBOL statements can be made more efficient at the expense of clarity and conciseness; the pattern could be assigned to a variable which would then be used in the matching, for example. However, the view taken here is that one would thus lose virtually all the advantages of using the language.

Some of the LFP System programs, notably LFPG01 (the program generator) and PRINT, make extensive use of data in list structures and PL/1 provides adequate facilities for this in its based storage and pointer-type variables and in permitting recursion. The procedure PGPHL called by the program generator (p.352 of ref.125) is probably the richest example of the use of these language features within the present system. An identifier with the "based storage class" can represent any data-type permitted to normal identifiers or it can be a structure of variables of diverse types and is regarded as a template which can be laid over any area in the program's core storage and used

to refer to fields within that area. Its position is determined dynamically by a "qualifying" pointer variable which effectively takes as values addresses in core. A based structure may contain pointers, so chaining is possible. The following excessively simple example illustrates the feature. We declare a based structure, ELEMENT, and two pointer variables:

```
DCL 1 ELEMENT BASED(P), 2 LINK POINTER,
                        2 VALUE CHARACTER(10);
DCL (HEAD,P) POINTER;
```

Assume that there is, in core, a list of character strings:



and that HEAD points to the first of them. The following PL/1 statements will print out the contents of the list, because ELEMENT will refer to whatever location in core is addressed by P, and as P changes ELEMENT (the template) moves.

```
     P=HEAD;
LOOP:IF P=NULL THEN GOTO EXIT;
     PUT LIST(ELEMENT.VALUE);
     P=ELEMENT.LINK;   GOTO LOOP;
EXIT:
```

It can be seen that, as with its "string" processing, PL/1's "list" processing features do no more than provide the programmer with the type of addressing capability which the assembler programmer has and enables him to implement his own list processor. Comments similar to those made about the utility of string processing languages can be made with regard to list processing. The ability to manipulate lists, trees, etc. without worrying about addresses (i.e. to be able to call a list a list) would be useful in the program design stage and a suitable language for a many facetted application would probably be similar to LISP 2[106] which is an ALGOL-like, extended version of the notationally cumbersome LISP 1.5[127].

Dolby et al.[86] discuss programming languages in the context of library applications of computers and point out that PL/1, in attempting to be all things to all programmers, is an

expensive language to use and is restricted to large machines. An Assembly Language control section equivalent to procedure FLEX (p.202, ref.125) was written to provide an indication of the storage savings possible over optimized PL/1 modules. Figure 10.1 gives the result; it should be pointed out that the PL/1 library routines used by FLEX are also used by other parts of program PRINT, which calls FLEX, so the PL/1 version of FLEX is not as comparatively expensive as the "Totals" column might suggest. It is nevertheless clear that had the LFP System been written in the Assembly Language, it would have been so much less extravagant on core storage that a totally different approach could have been taken to the overlaying of program modules which might have resulted in a one-step job design instead of the present four. It is estimated that CPU times for PL/1 programs in this field can

	Storage occupied by loaded FLEX (bytes)	Storage occupied by library routines (bytes)	Totals
PL/1 procedure	7250	8994	16244
Assembler CSECT	1280	none	1280

Figure 10.1 Storage comparison: PL/1 v. Assembler

be improved by a factor of 2.5 times simply by recoding in assembler, and the old view that it is not important to make savings of this order while processor time is swamped by I/O time is no longer valid in the environment of multiprogramming and time-sharing, where a major goal of the operating system is to maximize usage of the central resources. The other major high-level language which has been used in library applications, COBOL[108,38,25], suffers similar disadvantages, is less suitable as a language, but is more widely known and available to programmers. It has often been assumed that an advantage of high-level languages is that even inexperienced, occasional or novice programmers can produce useable software. However, this advantage may be insignificant in comparison with the desirability of the services of computer specialists for any large scale automation project. Dolby[113] examines programming language structure statistically and draws analogies between executable units and elements of natural language. The statements of a programming language behave like letters of the alphabet and sequences of them like words; although the set of letters is small and bounded, the set of words is not. In order to invent a "super language" for library applications, we need to know the most commonly used, managable-sized subset of the possible sequences of instructions. One useful approach for a large programming job is to use the macro facility which

most assemblers (or equivalent) now have; thus a machine can be "moulded" into a more convenient tool.

10.2 *SYSTEM CONSIDERATIONS*

Among the first things that an applications programmer usually wishes to do when his system is complete and in operation is to redesign it. Any future version of the LFP System should be written in the Assembly Language with extensive use of the macro facility, and many of the algorithms can be improved. The Michigan Terminal System (MTS) in use on NUMAC looks more attractive than 360/OS for this application. MTS[128] is a time-sharing system which supports both batch processing (with, predominantly, card readers and line-printers) and on-line terminals (typewriters and character display units). There is very little to be gained in performing the currently implemented tasks on-line, and some of them positively should not be done at a console, but a new design would no doubt take advantage of the conversational facility for small file maintenance jobs. A definite advantage of MTS over OS in the NUMAC installation is that the daily timetable "favours" MTS and one may expect faster turn around time for jobs run under that system. The most important advantage of MTS from the point of view of the library, and most other users, is the conceptual simplicity of its command language (equivalent of 360/OS Job Control Language) and file management.

Specific ideas for expansion of the LFP System have frequently occurred during the year in which it has been in routine operation; three areas are discussed here.

(i) An ordering sub-system would be a useful addition. Routines exist in the system to select from a file records of books which require ordering or whose arrival is awaited, etc., to print orders, reminders and lists, and to systematically change the records' status. Programs of commands to do these tasks are clumsy, however, and the financial aspects of the operation are completely absent. This is ironical in view of the original request of the library. However, once the book collection had been set up, the necessity for a sophisticated ordering system diminished*; orders were dispatched in small, irregular batches, and a substantial proportion of the stock was transferred, often temporarily, from the main library's shelves.

(ii) The record selection feature (see section 4.4 of

*The first 1500, or so, orders were prepared with a totally different, and now obsolete, set of programs.

Chapter 4) is capable of considerable improvement. One should be able to write a general boolean expression involving the value of any element in the item and various other characteristics of the item, such as "number of course codes greater than 1". It might also be desirable to extend the use of the selection specification to all input files in internal format. The syntax of input file parameters might be:

filename [(select)]

One could then write the following command, for example:

```
SORT INFILE ('#400=F') OUTFILE SEQ701;
```

which would sort the items, in file INFILE, associated with French courses into title order, putting the sorted records into file OUTFILE.

(iii) The facility for printing formatted lists (program PRINT, Chapter 6) is capable of endless improvement! The HEADING statement (p.84) is restrictive and should be removed from the print-control language. Its effect could be achieved as a special case of an enhanced format statement (p.81) in which literal constants would be permitted wherever element tags are now. For example:

```
20,('ITEM NO.',1,#100,1,'IS',1,#701,1,'BY',1,#601),
   CONT IN 22, STOP IN 95;
```

A similar extension to the group heading statements (p.79) would allow the user to specify column headings for a fully or partially tabulated listing. Another facility which might be added is the optional truncation of text during formatting to force it into a specified number of lines; a strictly one-line-per-item listing cannot be produced with the present version of the program. Contraction of text would be desirable in some situations; e.g.

```
WEBER M.   THEORY OF SOCIAL AND ECON...ED.T.PARSONS
```

may be preferable to

```
WEBER M.   THEORY OF SOCIAL AND ECONOMIC ORGANISATI
```

Finally it would be useful to be able to ask for a double column layout.

The chapter concludes with some suggestions for features of a hypothetical, new overall design for the LFP System. The opportunity has not arisen to follow these up, but it is believed that the technical difficulties are not significantly greater than those encountered in the implementation of the present system.

(i) The system should be a "one-step" system, i.e. the user should need to initiate the execution of only one program which would both read his commands and call upon the appropriate "library" programs to obey them. Dynamic loading of the modules is required for this approach (as opposed to the planned overlay structure created for the present system by the program generator - see ref.120 and p.304 of ref.125).

(ii) A more flexible method is required of handling card files which, in a new system, would include lines typed in at an on-line terminal. It should be possible to intermingle commands, print-control instruction sets and data (externally formatted bibliographic records, for instance); and, to take advantage of previously stored files, a comprehensive "file-switching" facility should be incorporated (something like, but more versatile than, the GO statement, p.86).

(iii) The modular approach of the LFP System is the basis of the system's versatility. The user can quickly specify any combination of processes to be performed upon files which are also his to nominate. A disadvantage of this method is that often a file must be sequentially processed (read or written) more than once where a special purpose program could be constructed to perform the function with a single pass of the file. For example, in the following pair of commands, file TEMP is processed twice unnecessarily:

```
FINPUT INDATA 80 ON TEMP BJPX '' ABCDEF ' ';
UPDATE LBK TEMP LBK OFF;
```

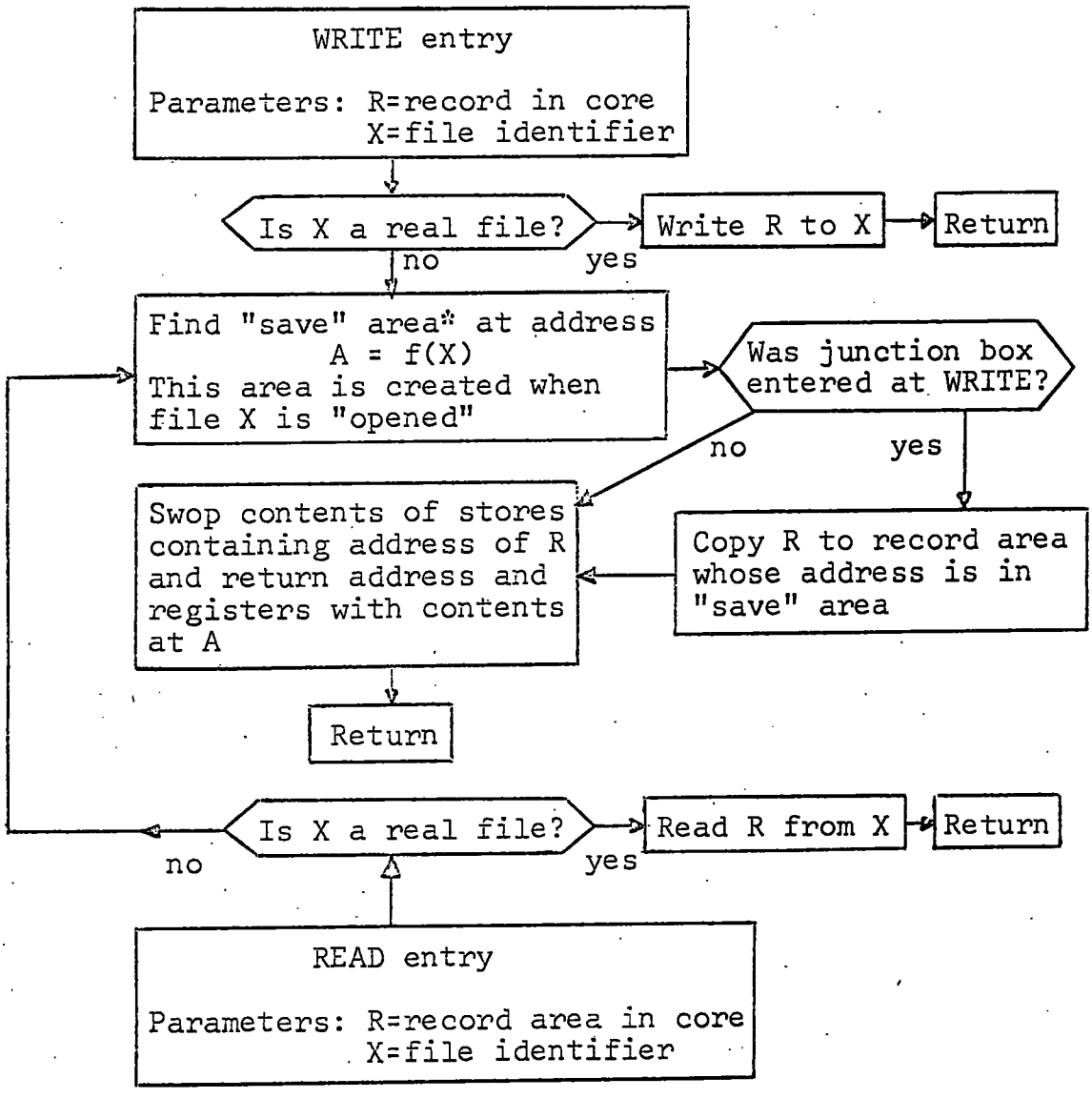
The file TEMP read by program UPDATE contains the very records written into it by program FINPUT. That statement is not true for the following example:

```
FINPUT INDATA 80 ON TEMP BJPX '' ABCDEF ' ';
SORT TEMP TEMP SEQ100;
UPDATE LBK TEMP LBK OFF;
```

It is, however, true that SORT reads the records as prepared by FINPUT and that UPDATE reads those finally

written by SORT. Programs which combined the functions of FINPUT and UPDATE or of FINPUT, SORT and UPDATE would run more efficiently, but the modularity and hence versatility of the system would suffer.

It may be possible to produce an algorithm for deciding whether a file to be read by one program will be unchanged from its state when another program wrote it. An approach which is easier to implement is to ask the user to identify the files. A programming technique which is essentially the construction of a set of coroutines can then be used to satisfy both objectives - modularity and efficiency (the marked files are never actually written onto the disk). The central part of this method is a re-entrant routine, which might be called a "coroutine junction box", with two entry points READ and WRITE. When a program such as UPDATE is required to read a record it calls READ using normal subroutine linkage, and when it must write a record it calls WRITE. Figure 10.2 is a simple flowchart containing the important features of the junction box module, and figure 10.3 shows how control flows in two programs which are linked through it. The junction box acts just like an ordinary input/output routine if the file involved is a real file on a storage device, otherwise it effectively passes records one at a time from one program directly to another. In figure 10.3 the programs are highly simplified - one call represents all the calls in the program for that pseudo-file. The process starts by creating a save area for pseudo-file @X, setting the entry point of Program 1 as the "return" address in that area and entering Program 2. At the first READ from @X the address of the record area, T, is saved together with the return address in Program 2 and control passes to the beginning of Program 1. When a WRITE is encountered, the record is copied to the address last saved upon READing and control returns to the point after that READ invocation. Because the junction box is re-entrant, it can be used by any number of pairs of programs concurrently, and in that case it is possible that a program will be in multiple, simultaneous use, so it also must be re-entrant. Coping with the ends of pseudo-files and with cases where a pseudo-file is read by more than one program (it cannot, by definition, be written by more than one) is not dealt with here, but is quite straightforward.



* The "save" area contains fields for all the registers which are normally assumed, by calling programs, to be preserved. In particular, it contains a field for a return address and one for the address of a record area in core. The "save" area is not used in the conventional way, i.e. it is not filled up on entry to the control section.

Figure 10.2 The "coroutine junction box"

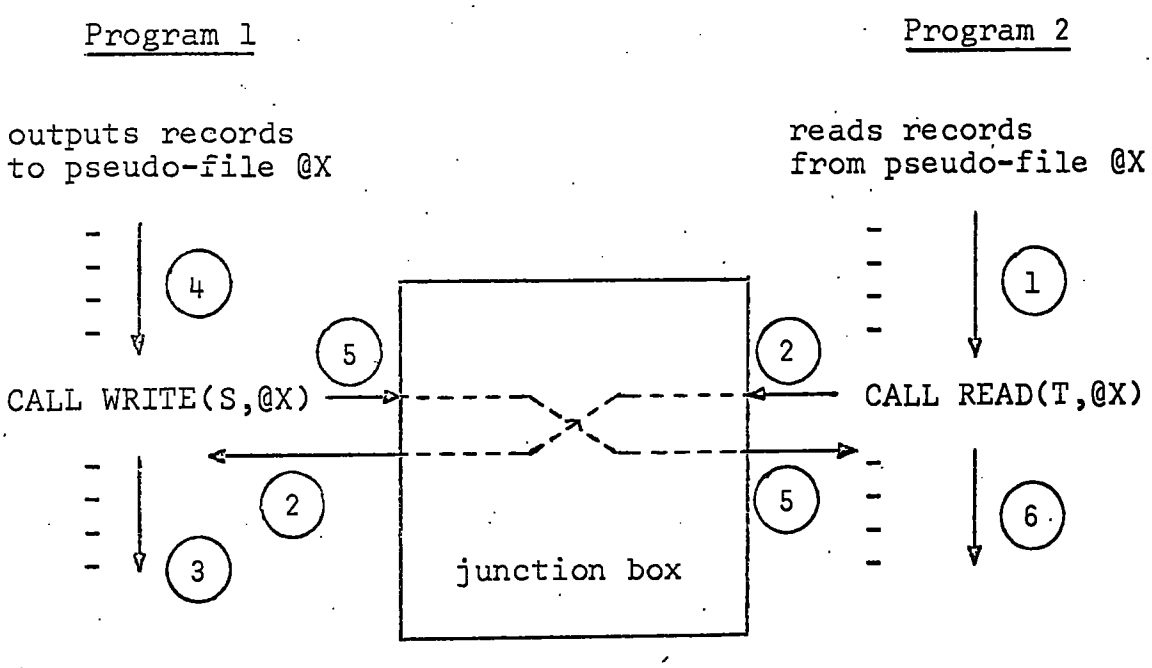


Figure 10.3 Flow of control when processing pseudo-files. The numbers on the arrows signify the order in which they are followed (1 to 6, cyclically).

Using the character '@' to prefix pseudo-files, the last example above might be rewritten, more efficiently,

```
FINPUT INDATA 80 ON @A BJPX '' ABCDEF ' ';
SORT @A @B SEQ100;
UPDATE LBK @B LBK OFF;

END;
```

BIBLIOGRAPHY

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The following abbreviations are used for the names of periodicals:

Am.Doc. = American Documentation, which became JASIS with volume 21 in 1970

CRL = College and Research Libraries

JASIS = Journal of the American Society for Information Science

J.Doc. = Journal of Documentation

JOLA = Journal of Library Automation

LRTS = Library Resources and Technical Services

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LFP SYSTEM

USER'S SUMMARY

Appendix 

1. *PROGRAMS*

Program name	Function	Reference Section	Reference Page
BATCH	Reads a card file containing externally formatted items and special instructions (BATCH and SELECT) for generating items and produces an external file suitable for conversion by program FINPUT.	9.3 9.2	149 144
CDLIST	Produces a listing of a card file.	9.5	156
CHKSRT	Examines an internally formatted file to see it is in a specified order.	5.4 5.1	64 56
CODEIN	Reads a card file containing information needed to decode certain of the coded elements and creates a code translation file for use by program PRINT.	8.2 8.1 6.2	137 128 77
COIND	Prints indices, in alphabetical order of codes and of translations, of the course codes (#401) occuring in an internal file.	8.3	140
FCOPY	Makes copies of items in an internal file. The copy may be selective.	4.3 4.4	49 52
FINPUT	Converts a file of bibliographic records from the external to the internal updating format.	4.1 3.4	39 34
FPUNCH	Converts a file of bibliographic records from the internal to the external format.	9.1	142

Program name	Function	Reference Section	Reference Page
IMAGE	Copies a card file with optional renumbering. Can be used to store programs of commands and sets of print-control statements.	9.4	152
MERGE	Combines two internal files, assumed to be already sorted into a specified order, to produce a single sorted file.	5.3 5.1	61 56
PRINT	Reads print-control statements from one or more card files and prints items from internal file(s) as instructed.	Chapter 6	67
RUNOFF	Copies a file containing the output of a previous job to the printer as many times as required.	9.6	157
SORT	Arranges the items in an internal file into a specified order.	5.2 5.1	59 56
UPDATE	Updates an internal file, using the items in another internal file (in updating format).	4.2 3.3 7.1	42 32 94

2. *COMMAND LANGUAGE*

Statement type	Function	Reference Section	Reference Page
Command	Invokes one of the above programs and specifies information which may vary from one application to another, such as the names of files involved.	7.2 7.6	98 124

Statement type	Function	Reference Section	Reference Page
Conditional	Performs a comparison, the result of which determines which statement is obeyed next. The numbers compared are either given explicitly in the conditional statement or set on completion of previously executed commands in the program.	7.2 7.6	102 125
END	Marks the end of the program. When this statement is executed, the job step terminates.	7.2	107
GOTO	Instructs the computer to obey a specified statement next (instead of following the statements in sequence).	7.2	105
IF	(see "Conditional" above)		
PROGRAM	Obligatory first statement in a program of commands. May name the program.	7.2	102

3. *PRINT-CONTROL STATEMENTS*

Statement type	Function	Reference* Page
END	Indicates end of set of statements. After the printing, PRINT terminates. (See "execute").	86
execute	Instructs PRINT to execute the listing requested in the preceding statements and specifies what is to be done next. END and GO are the execute statements.	86

*All details concerning print-control statements are in Section 6.2.

Statement type	Function	Reference Page
format	Specifies a text to be constructed of one or more elements and gives the layout on the printed page.	81 75
GO	An execute statement. After printing, program PRINT is to interpret another set of instructions in the file specified by the GO statement.	86
group heading	Identifies an element, the values of which are to be printed as headings above groups of items which have that element-value in common. LINE and PAGE statements are group heading statements.	79
HEADING	Inserts a line of text in each item that is printed.	84
LINE	A group heading statement. A new heading is printed on a new line.	79
LIST	Specifies the file(s) to be printed.	73
PAGE	A group heading statement. A new heading is printed at the top of a new page.	79
PRINT	(same as LIST, above)	
SELECT	Gives a selection specification (see Section 4.4) to be applied to all items read from the file(s) given in LIST or PRINT statements.	74
SKIP	Causes a new line to be started while formatting an item for printing. Blank lines can be included.	79
SPACE	Specifies the number of blank lines required between printed items.	75

PREPARATION OF EXTERNAL FILES

Appendix B

This appendix contains, as samples, instructions used in Durham University for:

(i) (Library instructions) Completion of updating forms (abridged).

(ii) (Computer Unit instructions) Key-punching details from the forms onto 80-column cards to produce external files.

Most of the detail is local, conventional application of the general rules given in Chapter 3. Figure B.1 illustrates two completed forms and figure B.2 shows how the items might be punched in an external file.

B.1 COMPLETION OF FORMS

General notes

(i) Alphabetical characters are written in capitals.

(ii) Write clearly. Use the following convention:

letter O numeral Ø

It should be clear where blanks (spaces) are intended: use the symbol ß if the occurrence of the space is not obvious or if more spaces than one are required in consecutive positions.

(iii) The characters # and * may not be written in any box on the form. £ may be used for one purpose only (see iv). Prices should never be written with the £ sign.

(iv) The updating form is used both to add new items to the files and to alter items already there. When writing a form for a new item, enter information in the appropriate boxes. Any combination of boxes (but always including the item no.) may be used. To amend an existing item, fill in the "Item no." box and enter the altered or new details in the appropriate boxes. Whatever is written in the box completely replaces any previous element in that position. To remove an element from the stored item, enter £ in the box.

#100 Item no. D0544	LIBRARY COMPUTER FILE UPDATING FORM	Delete (tick)	Continuation no.

#102 Type	#200 Agent COM	#201 Order date 15/8/68	#202 Receipt date 12/9/68
#300 Status E	#302 Price 2.50	#500 Pub.date 1968	#801 Class 192.9
#401 Course [illegible]M	#402 DPR	#403	#404

#405 | #406

#601 Author
LEWIS H.D.(ED.)

#701 Title
CONTEMPORARY BRITISH PHILOSOPHY SERIES 3. 2ND ED.

#900 Publisher
ALLEN & UNWIN

Continued (tick)

#100 Item no. D1641	LIBRARY COMPUTER FILE UPDATING FORM	Delete (tick) 1	Continuation no.

#102 Type [illegible]	#200 Agent	#201 Order date	#202 Receipt date
#300 Status [illegible]	#302 Price	#500 Pub.date [illegible]	#801 Class
#401 Course	#402 MAP	#403	#404

#405 | #406

#601 Author
#602 DEVIZES MUSEUM (SHELVED AT ANNABLE)

#701 Title

#900 Publisher

Continued (tick)

Figure B.1. Items on Updating Forms. A new item (top) and a typical amendment to an existing item.

```
#100 D0544£ #200 COM£ #201 13/8/68£ #202 12/9/68£ #300 E£ #302 2.50£ #500 1956£
#801 192.9£ #401 DDM£ #402 DPR£ #601 LEWIS H.D.(ED.)£ #701 CONTEMPORARY BRITISH
PHILOSOPHY SERIES 3. 2ND ED.£ #900 ALLEN & UNWIN£ *

#100 D1641£ #102 £ #300 F£ #500 1964£ #402 MAF£ #602 DEVIZES MUSEUM (SHELVED AT
ANNABLE)£ *
```

```
                                                                    column 73
                                                                    v
#100 D0544£ #200 COM£ #201 13/8/68£ #202 12/9/68£ #300 E£ #302 2.50£ #5000002180
0 1956£ #801 192.9£ #401 DDM£ #402 DPR£ #601 LEWIS H.D.(ED.)£ #701 CONTE00002190
MPORARY BRITISH PHILOSOPHY SERIES 3. 2ND ED.£ #900 ALLEN & UNWIN£ *     00002200

#100 D1641£ #102 £ #300 F£ #500 1964£ #402 MAF£ #602 DEVIZES MUSEUM (SHE00031770
LVED AT ANNABLE)£ *                                                    00031780
```

Figure B.2 Externally formatted items.
Two ways of punching the items in figure B.1, firstly without and then with card numbering in columns 73 - 80.

(v) To have an item deleted from a file, enter the item number only and tick the "Delete" box. The item will no longer exist on the file and will not, therefore, appear on printouts. A dated manual record of deletions should be kept.

(vi) Details can be continued on one or more further files if there are more elements in a range than are allowed for on the form, e.g. more than one author or more than six courses. Tick the "Continued" box on the original updating form, number subsequent forms 1, 2, etc. in the "Continuation no." box, and repeat the item no. each time. Elements (such as long titles) should not be split between forms, but if necessary a special note to the punch operator attached.

Notes about the boxes

(vii) #1ØØ Item no.

Every completed form, including continuation forms, must bear an item number 5 characters long. In Durham, "numbers" consist of a letter and 4 digits, e.g. D1931. This is the record identification for updating processes; it is essential to enter the correct item numbers for amendments and deletions and of course to avoid duplicating numbers. In order that an item should appear in catalogues and lists, it must exist in a file and have an "item no.". There may be items without exactly corresponding books.

(viii) #1Ø2 Type

A single letter, selected from the code list, indicating the type of publication.

J means that the item is a periodical article,

M means that it is a Bobbs-Merrill reprint.

Leave the box blank for all other items.

(ix) #2ØØ Agent

A three-letter code indicating the supplier of the book (consult code list).

(x) #2Ø1 Order date and #2Ø2 Receipt date

Use the form 29/11/69

(xi) #3ØØ Status

A one-letter code chosen from the following list:

A	to be ordered
B	to be ordered (copy transferred from main collection meanwhile)
C	on order
D	on order (copy transferred)
E	received
F	transferred copy, not ordered (including books borrowed from elsewhere)
G	cancelled order (no transfer available)
H	withdrawn after receipt
J	withdrawn transfer
M	transferred for Michaelmas term only
P	transferred for Epiphany term only
R	transferred for Easter term only
T	transferred for Michaelmas and Epiphany terms only
V	transferred for Epiphany and Easter terms only
X	transferred for Easter and Michaelmas terms only

Note. Statuses M, P, R, etc. are for books for which demand is cyclic and the copy is moved into and out of the collection. The item remains in the files all the time but only appears in catalogues when the book is "in". Statuses G - J allow records to be kept of unsuccessful orders etc., and of books put into limbo when demand evaporates.

(xii) #3Ø2 Price

Use the form pounds.pence, e.g. 2.50

(there must be two numbers, so 5Øp is written 0.50).

(xiii) #4Ø1 Course, #4Ø2, etc.

Enter three-letter codes, from the code list, for the course(s) for which the item is recommended. If more than 6 codes are required, alter the

numerical tags and use continuation forms as necessary. For example:

~~#401~~ Course	~~#402~~	#403
#407 JDA	#408 Z	

When a file is sorted for printing a course catalogue, additional entries are generated so that an item will appear in as many places as it has course codes.

(xiv) #500 Publication date

Enter year of publication of this edition.

(xv) #601 Author

Surname first, then initials (no commas). If the 'author' is an editor, (ED) follows. Two authors' names are separated by &. If there are more than two, the first is given, followed by AND OTHERS. (Note that & files before A) For works of joint editorship, add (EDD) to the end of the element.

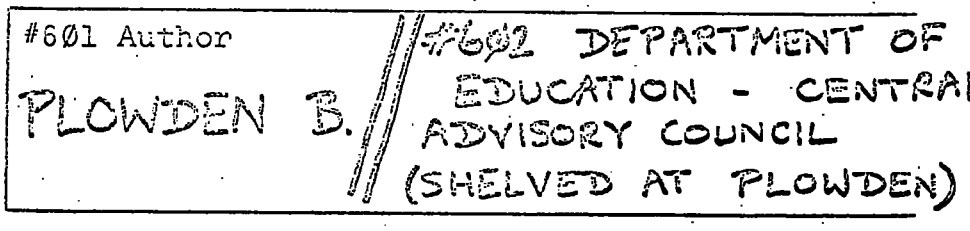
Examples

LIPSET S.M.
LIPSET S.M. & BENDIX R.
LIPSET S.M. AND OTHERS
LUARD E.(ED)
MORGAN T. AND OTHERS(EDD)

Official publications are entered under the issuing body, e.g. DEPARTMENT OF ECONOMIC AFFAIRS.

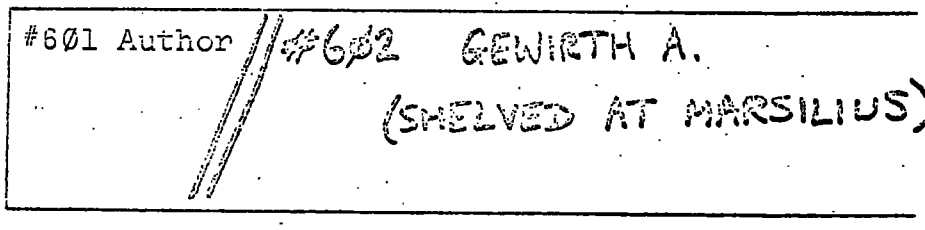
(xvi) Further author entries, #602, #603, etc.

The following comments also apply to additional titles (#702,#703, etc.) and class numbers (#802,#803, etc.). When a file is sorted into author order, an extra item will be generated and filed for each additional author, tagged #602, etc., and these will be printed as added entries.

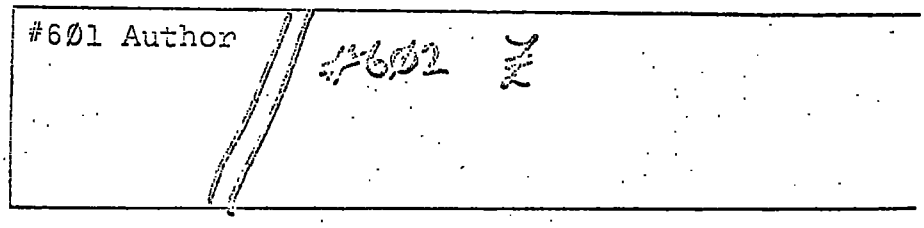


Material is shelved according to the main author (#601), so reference to it is included in added author entries.

To add another author entry, or when using a continuation form:



To remove the 2nd author:



(xvii) #701 Title

The sorting programs determine the order of the items by straightforward character comparisons; space comes first, followed by punctuation, then the letters in alphabetical order and lastly the numerals 0-9 (see Chapter 3, figure 3.1). Delete articles, prepositions and other non-significant words from the beginning of titles, and be sparing and consistent in the use of punctuation and quotation marks. Edition, volumes and editor (where different from the author) are given at the end of the title, e.g.

6TH ED. 3V VOL 2 ED. J.SMITH

Additional titles (#702, etc.) are permissible in the same way as authors (see xvi).

(xviii) #801 Class

Dewey number. Additional class numbers (#802, etc.) are allowed (see xvi).

(xix) #900 Publisher

This box is used for three purposes. If a book is to be ordered, enter the publisher, and SBN. If the item is a periodical article (xerox copy, etc.) enter journal reference prefixed by 7, e.g.

7 BR.J SOCIOL. 12 PP 9-17

Alternatively, if there is important information concerning the item, which cannot be accommodated in the record, use the Publisher box for notes, prefixed by 9, e.g.

9 CONSULT MANUAL RECORD FOR STATUS

(xx) Send the completed forms to the computer data preparation service with any general instructions, concerning card numbering for instance, attached.

B.2 KEYPUNCHING FROM FORMS

Note

In Durham University, the average speed of key-punching has been found to be 10,000 keystrokes per hour, working directly from forms such as those in figure B.1.

General punching instructions

An item is all the data written on one or more forms. Normally, it will all be on one form, but if the "Continued" box is ticked, expect to find a number in the "Continuation no." box on the next form. In the latter case, the Item goes on to include all forms up to and including the first one without the "Continued" box ticked.

Work through each Item looking for boxes to the right of the numbers which have something written in them. For each of these boxes, type the number followed by one space, the contents of the box, the £ symbol (unless the box itself contains a £ already) and another space.

e.g.

#201 Order date	#202 Receipt date
7/3/70	£

would be punched

#201 7/3/70£ #202 £

Note. If a continuation form has the "#100" box filled in, ignore the number; it is only there for reference.

At the end of each Item, type *

Special cases

1. If the "Delete" box is ticked, punch the "#100" box followed by

DELETE£ *

and ignore anything else which might appear on the form (and continuation forms, if any)

e.g.

#100 Item no.	LIBRARY COMPUTER FILE UPDATING FORM	Delete (tick)
D0753		✓

would be punched

#100 D0753£ DELETE£ *

2. Extra boxes might have been created on a form.

e.g.

#601 Author	#602
JONES G.	SMITH H.

would be punched

#601 JONES G.£ #602 SMITH H.£

e.g.

#801 Class // #802 330.4

would be punched

#802 330.4£ (There is no #801)

Appendix C

THE CATALOGUED PROCEDURE DLFPMCLG

The catalogued procedure (DLFPMCLG) used in Durham University for the operation of the LFP System is shown in figure C.1. All of the sample jobs given in the thesis make use of DLFPMCLG. It consists of job control statements for four job steps labelled M,C,L and G. We shall describe the steps in turn.

(i) Step M. The Library File Program Generator (PGM=LFPG01) is executed.

STEPLIB defines the program library containing LFPG01,

SYSPL1 will contain the PL/1 program generated by LFPG01,

SYSLIN is for Linkage Editor control statements generated by LFPG01.

The user must supply a card file called SYSIN containing a program of commands.

(ii) Step C. The PL/1(F) Compiler (PGM=IEMAA) is executed.

SYSIN is the file containing the PL/1 program generated in step M,

SYSLIN will contain the compiled program.

The user need not normally override this step.

(iii) Step L. The Linkage Editor (PGM=IEWL) is executed.

SYSLIN contains both the compiled program from step C and the control statements from step M,

SYSOBJ defines the library of LFP System programs (FINPUT, SORT, etc.),

SYSLMOD will contain the complete program to obey the commands entered by the user in step M.

The user need not normally override step L.

(iv) Step G. The program which step L stored in file SYSLMOD is now executed. The following files are defined and the user must supply any other

```
//M       EXEC PGM=LFPG01                                                  00000010
//STEPLIB DD DSN=LOAD.DUL01,UNIT=2314,VOL=SER=UNE040,DISP=SHR              00000020
//SYSPRINT DD SYSOUT=A                                                     00000030
//SYSUT1 DD UNIT=2314,VOL=SER=UNE030,SPACE=(CYL,(1,1))                     00000040
//SYSPL1 DD UNIT=2314,VOL=SER=UNE999,SPACE=(CYL,(1,1)),DISP=(,PASS)        00000050
//SYSLIN DD UNIT=2314,VOL=SER=UNE999,SPACE=(CYL,(1,1)),DISP=(,PASS)        00000060
//C       EXEC PGM=IEMAA,PARM='S,A,X,NT,NOL,NST',COND=(5,LT,M)             00000070
//SYSPRINT DD DUMMY                                                        00000080
//SYSLIN DD UNIT=2314,VOL=SER=UNE999,SPACE=(CYL,(1,1)),DISP=(,PASS)        00000090
//SYSUT1 DD UNIT=2314,VOL=SER=UNE999,SPACE=(CYL,(2,1))                     00000100
//SYSUT3 DD UNIT=2314,VOL=SER=UNE999,SPACE=(CYL,(2,1))                     00000110
//SYSIN  DD DSN=*.M.SYSPL1,DISP=(OLD,DELETE)                               00000120
//L       EXEC PGM=IEWL,PARM='OVLY,LIST',COND=((5,LT,M),(5,LT,C))          00000130
//SYSPRINT DD DUMMY                                                        00000140
//SYSLIN DD DSN=*.C.SYSLIN,DISP=(OLD,DELETE)                               00000150
//       DD DSN=*.M.SYSLIN,DISP=(OLD,DELETE)                               00000160
//SYSLIB DD DSN=SYS1.PL1LIB,DISP=SHR                                       00000170
//SYSLMOD DD DSN=&G(MAIN),UNIT=2314,VOL=SER=UNE999,SPACE=(CYL,(1,1,2)),    00000180
//          DISP=(,PASS)                                                   00000190
//SYSOBJ DD DSN=OBJ.DUL01,UNIT=2314,VOL=SER=UNE040,DISP=SHR                00000200
//SYSUT1 DD UNIT=2314,VOL=SER=UNE999,SPACE=(CYL,(2,1))                     00000210
//G       EXEC PGM=*.L.SYSLMOD,COND=((5,LT,M),(5,LT,C),(5,LT,L))           00000220
//DUMMY  DD DUMMY                                                          00000230
//SYSPRINT DD SYSOUT=A                                                     00000240
//SYSCODE DD DSN=DUL01LCO,UNIT=2314,VOL=SER=UNE040,DISP=SHR,               00000250
//          DCB=(RECFM=F,LRECL=66,DSORG=DA)                                00000260
//WORK1 DD UNIT=2314,VOL=SER=UNE999,SPACE=(CYL,(5,1))                      00000270
```

Figure C.1 DLFPMCLG - Catalogued Procedure

file definitions required by his program.

DUMMY (see page 114 in Chapter 7),

SYSPRINT for printer output,

SYSCODE is an extant code translation file (see Chapter 8),

WORK1, for temporary working space, can be used either for card files or for internal files (but not both in the same job step) and will take up to 28,000 card records or 18,000 ("Durham-sized") internally formatted items.