

**UTILITY SYSTEM
PROGRAMMING
MANUAL**

LINC-8

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FOREWORD

Digital Equipment Corporation derived this publication from a document entitled "A LINC Utility System," written by M. D. McDonald, S. R. Davisson, and J. R. Cox, Jr. (Technical Report No. 1, Biomedical Computer Laboratory, St. Louis, Missouri, March 1965) at the Biomedical Computer Laboratory of Washington University School of Medicine, St. Louis, Missouri. A copy of the preface to that document is included in this publication for completeness. To the above individuals, as well as others at the Washington University School of Medicine, the National Institutes of Health, the National Aeronautics and Space Administration, the Massachusetts Institute of Technology, and individual LINC users, we are greatly indebted.

The convenience programs originally presented in "A LINC Utility System" have been removed from this document and are located under separate cover in the LINC-8 Program Library along with other useful programming information. The program descriptions in this manual are written for the LINC-8 System operated in conjunction with the standard LINC keyboard. When the LINC-8 is used with the ASR-33 Teleprinter, refer to the LINC/ASCII Code Conversion information presented in chapter 4, chart 4.2.

Preface To Technical Report No. 1

Biomedical Computer Laboratory

St. Louis, Missouri, March 1965

This utility system has been developed at the Biomedical Computer Laboratory of Washington University School of Medicine to aid in the preparation and execution of LINC programs. It consists of two communicating systems, LAP4 and GUIDE. LAP4 is a descendant of LAP3 which was written by Mary Allen Wilkes in 1963 while at the Center Development Office of the Massachusetts Institute of Technology. The major structure of LAP3 has had few changes, but five of the meta commands have been substantially changed (DISPLAY, ADD MANUSCRIPT, CONVERT, CONVERT MANUSCRIPTS and COPY) and three new meta commands have been added (START LAP, START GUIDE, and MANUSCRIPT CONTROL). The LAP4 section of this manual is based upon the LAP3 manual prepared by Miss Wilkes. It has been changed and augmented where necessary to describe the LAP4 system. GUIDE is a completely new system, having been conceived a little over a year ago. All of the programming has been done by two of us (M. D. McD. and S. R. D.), but all three participated in the development and the documentation of the two systems. Several convenience programs are included in section 4. Authorship of these programs is indicated by the initials in the upper right-hand corner of the page.

The original development of LAP3 was supported in part by a contract (PH 43-63-540) with the Division of Research Facilities and Resources of the National Institutes of Health, in cooperation with the Bio-Sciences office of the National Aeronautics and Space Administration. The development of LAP4, GUIDE and convenience programs was supported by a grant (FR-00161-01) from the Division of Research Facilities and Resources of the National Institutes of Health.

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CHAPTER 1 INTRODUCTION

1.1 SYSTEM DESCRIPTION

This is a reference manual for a utility system for the LINC-8. The reader is assumed to have a basic familiarity with programming for digital computers, binary and octal number systems, and the LINC-8 order code and control console. All programs and systems described herein are executed by the LINC-8.

Two independent but communicating systems, LAP4 (LINC Assembly Program 4) and GUIDE (A Guide to Binary Programs) comprise this utility system. These systems were written to perform useful functions in the creation and manipulation of symbolic (source) programs and the filing and execution of binary (object) programs. In this utility system, a symbolic program consists of a sequence of lines of alphanumeric characters called a manuscript (MS). A binary program may be generated from the manuscript of a symbolic program and consists of a sequence of coded instructions directly interpretable by the control section of the LINC-8. LAP4 operates on the manuscript of a symbolic program and aids in its creation, display, filing and retrieval, modification, and conversion to a binary program. GUIDE operates on binary programs and assists in the maintenance of a file of binary programs and in the execution of programs in this file.

1.2 SYSTEM TAPE STRUCTURE

A system tape, containing both the LAP4 and the GUIDE systems, has the following structure:

<u>Blocks</u>	<u>Use</u>
0 - 12	automatic loading programs
270 - 327	used for the LAP4 system, i.e., all the routines necessary to perform the various functions ascribed to LAP4.
330 - 377	the LAP4 working area; serve as temporary storage for both the manuscript of a symbolic program during its preparation and also for the binary program generated from the manuscript.
400 - 407	used for the GUIDE system; i.e., all routines necessary to perform the activities attributed to GUIDE.
410 - 477	the GUIDE file area; serve as storage for the file of binary programs maintained by GUIDE.
0 - 77*, 100 - 177, 200 - 267, 500 - 577, 600 - 677, 700 - 777	available, but need not all be used, for files of manuscripts maintained by LAP4. *0 - 77 are not available on LINC-8 systems tape.

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The overall tape structure, and a more detailed description of the LAP4 and GUIDE tape areas can be found in chapter 4, charts 4.3, 4.4, and 4.5.

1.3 USAGE

Properly studied and correctly used, the LAP4 and GUIDE systems can enable the user to best use the LINC-8 for profitable research. Attempts to use the systems with incomplete knowledge can lead to dissatisfaction and improper use of the system. The systems deserve a proper initial approach such as suggested by the following syllabus:

1.3.1 Reading

Begin with a careful reading of the introductions to the LAP4 (chapter 2) and GUIDE (chapter 3) systems. Consult the glossary to become conversant with any unfamiliar terms and abbreviations. Then scan the remainder of the manual with a look at the charts of chapter 4 whenever they are mentioned.

1.3.2 Study

Next follow a program of careful study at the LINC-8 console. Begin with the general information on LAP4 described in chapter 2, and proceed to execute the operations described in this manual as you read about them. Many portions of both systems use a subroutine called Questions and Answers (Q&A), which displays information and questions on the scope and receives answers from the keyboard. A summary of the answering procedure for Q&A is on chart 4.8 and should be studied carefully. Only the LAP4 meta commands copy and manuscript control use Q&A, but all of the GUIDE system commands that require answers from the keyboard use Q&A.

1.3.3 Reference

Keep this manual nearby whenever using this utility system. A loose-leaf notebook is recommended. Tabs to identify the chapters are helpful and plastic covers for heavily used pages (particularly the charts in chapter 4) may be required.

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CHAPTER 2

LAP4 SYSTEM (LINC Assembly Program 4)

2.1 INTRODUCTION

Programming for digital computers may be accomplished in several source languages: the language of the machine itself (numbers); a language that substitutes mnemonics and symbols directly for the numbers; or a language, usually unrelated to that of the machine, that makes statement of the problem easier. These three programming methods, machine language, symbolic language, and problem-oriented language, are listed in the order of increasing complexity of the program required to interpret the source language.

Machine language is tedious because the programmer must use numerical operation codes and absolute numerical references to locations in core storage (addresses). So much detailed bookkeeping is necessary that the chance of an error is high for all except the shortest programs. A symbolic or assembly language relieves the programmer of much of this bookkeeping by allowing him to substitute mnemonics for the operation codes and to use symbols to identify addresses. A problem-oriented language may make the programming task still easier, because it often corresponds to the natural language of mathematics, business, or some special field.

Problem-oriented languages can be implemented on a computer in two modes. One of these modes, an interpreter, examines each statement in the source language in turn, chooses the appropriate subroutines, makes the required calculations, and moves on to the next statement. The other mode, compiler, examines the entire source program and translates it into a machine language program that will execute the task. Though extremely useful elsewhere, problem-oriented languages are particularly difficult to implement in situations in which the computer is strongly coupled to its environment.

2.2 THE LAP4 SYSTEM

LAP4 is an assembly program for the LINC-8, a computer that was designed to operate in the laboratory with strong coupling to both the investigator and his experiment. In this situation, the programmer himself is often the investigator and LAP4 makes it possible for him to prepare programs with the direct and immediate aid of the LINC-8. The source language is typed directly on the LINC-8 keyboard. The oscilloscope displays the correct line of manuscript and by providing immediate verification simplifies the correction of typographical errors. Manuscript is stored in blocks on LINC tape and can be retrieved for display and perhaps correction. Finally LAP4 converts the manuscript to a binary program and allows the programmer to save the manuscript for future reference and use. In contrast to many other systems, the programming job is accomplished through a rapid and continuing interaction between the programmer and the machine.

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The LAP4 system may be divided into three major sections: the input of manuscript, the manipulation of manuscript, and the conversion of manuscript.

2.2.1 Input of Manuscript

The programmer enters his program by typing on the keyboard with LAP4 in the regular input mode. He may, on a single line of his program manuscript, enter either a program line, an origin statement, an equality, or a comment.

A program line gives rise to binary output during the assembly process. It may be used for an instruction, a symbolic address, or an octal constant. Any program line may be assigned a symbolic location. An origin statement determines the location of a program section in memory. An equality assigns an absolute numerical value to a symbolic address or a symbolic constant. A comment is a manuscript line which is not necessary for, and is ignored by, the assembly process. Comments are any statements which the programmer finds useful for properly annotating his manuscript.

Manuscript lines are stored in quarter 3 of the LINC-8 memory as they are typed. When the quarter is filled, a block of manuscript is written on tape in the LAP4 working area (see chart 4.5.).

2.2.2 Manipulation of Manuscript

While in regular input, the programmer may wish to issue one of several special commands to the assembler. These special commands, called meta commands, provide for display, error correction, filing, and retrieving of manuscripts. Meta commands are entered and displayed in the same manner as ordinary lines of manuscript entered from the keyboard, but they are not retained in the manuscript.

2.2.3 Conversion of Manuscript

Conversion is the actual assembly process whereby LAP4 converts assembly language to binary machine language. Two additional meta commands which allow the assembly of a manuscript either in the working area or anywhere on tape unit 0 control this process. The LAP4 assembly is a 2-pass process; i.e., during assembly the manuscript is scanned twice from beginning to end. Pass 1 generates the binary corresponding to the symbolic operation mnemonics and tabulates the symbolic addresses and their corresponding absolute locations. Pass 2 generates the binary corresponding to the symbolic address references, the constants, the β references, and the i and μ bits.

LAP4 can detect certain symbolic address definition errors during assembly. An address defined more than once is detected by pass 1, and an undefined address is detected during pass 2. If such errors exist, the manuscript will be scanned a third time, pass 3, to particularize the errors and bring them to the attention of the programmer. The binary generated during the assembly process is placed in the LAP4 working area on tape in blocks 330-333.

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2.3 USING LAP4

Given below are a few recommendations for the use of LAP4 which, if followed, should minimize the number of steps necessary to proceed from a hand-written program to a correct, working, binary program.

- a. Type in the MS (manuscript), correcting indicated errors at once by retyping.
- b. Display the completed MS and proofread. If a Teletype is available, proofreading may be easier from printed copy. Correct all errors found with appropriate meta commands.
- c. Do not allow the MS to exist only in the LAP4 working area on tape; use the appropriate meta commands to store the MS elsewhere.
- d. Convert. Correct in the MS any undefined or multiple-defined addresses and reconvert.
- e. Execute the binary program and debug. See the description of the GUIDE system (chapter 3) for routines useful in execution and debugging; e.g., LAPRTN, return to LAP; FILEBI, file a binary program; MSPRNT, manuscript print; and MSQUIP, quick manuscript print.
- f. Return to LAP4 to correct any remaining errors.

2.4 LAP4 GENERAL INFORMATION

2.4.1 Operating Procedure

- a. LAP4 occupies blocks 270-327 of the tape, plus blocks 330 and following for working area (see chart 4.5). The tape must be on unit 0.
- b. To operate, read block 300 into quarter 0, and start at 0. A "0001" will appear on the scope to indicate that LAP4 is ready to accept keyboard input. LAP4 may also be initiated or restarted through GUIDE. (See LAPGO, start LAP and LAPRTN, return to LAP.)
- c. Lines of manuscript and meta commands are typed into the computer via the keyboard. LAP4 displays the information being typed on the scope, one line at a time, as it is keyed in.
- d. One quarter of the LINC memory collects manuscript. As the quarter is filled, it is saved on the tape beginning in block 336 of the working area. It takes approximately 100-110 (octal) lines of manuscript to fill one block.

2.4.2 Manuscript Lines

- a. By "manuscript line" is meant a line of program, a comment, an origin, or an equality. A meta command is not a line of manuscript.
- b. A manuscript line may not exceed 16_{10} struck characters. This includes spaces and case shifts. The terminator may be the 17th character.
- c. Manuscript lines are always terminated by striking the "end-of-line" key, EOL. LAP4 will not accept lines which are too long. (See Error Detection.)

2.4.3 Manuscript Line Numbers

- a. LAP4 assigns a line number to every line entered. The numbering appears at the upper left of the line on the scope; it is sequential, beginning with 1, and octal.
- b. The number 1 appears as the first line number when the initial "start 0" is executed. After that, a new line number appears every time the EOL is struck in terminating a manuscript line, and the computer waits for the next line to be typed.

2.4.4 Deleting

- a. Hitting the delete key del, deletes the current line. If there is no current line (i.e., if the computer is displaying only a line number), the previous line will be deleted. In either case, the line preceding the deleted line will appear on the scope; e.g., the following sequence will appear on the scope one line at a time as it is typed.

```

0001          ADD 3      ---hit EOL---
0002          STC 5      ---hit EOL---
0003          JMP 56     ---hit EOL---
0004          STA        ---hit del; line 4 is deleted---
0003          JMP 56     ---line 3 reappears; type line 4 again---
0004          STC 10     ---hit EOL---
0005          ---next line number appears; hit del---
0003          JMP 56     ---line 4 is deleted, line 3 reappears; hit del---
0002          STC 5      ---line 3 is deleted, line 2 reappears; continue---
```

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b. Whatever is "deleted" is permanently deleted from the manuscript. Whatever is displayed on the scope is the most recent line recorded. In the example above, only lines 1 and 2 are still part of the manuscript at the end of the sequence.

c. It is not necessary after a delete to hit EOL before continuing with the next line.

2.4.5 Display Format

a. The display format is as in the above example, one line at a time.

b. All keyboard characters (see chart 4.2) are displayed except EOL, del, CASE, and META.

c. Characters are displayed as they are struck.

2.4.6 Case Shift

a. Some keys on the keyboard have been assigned both upper and lower cases. The characters in the middle of the keys are lower case, and LAP4 normally interprets the keyboard as lower case.

b. To select upper case, hit the case shift key, CASE, and then hit the upper case character.

c. The shift is not permanent; it is good for one character only. LAP4 returns to lower case automatically.

d. LAP4 discontinues the display after CASE is struck, waits until the following upper case character is struck, and then resumes the display.

2.5 LINE FORMAT AND SYMBOLS

2.5.1 Origins

a. Origins must be specified as octal constants, preceded by an origin character, $\square$, and terminated with an EOL, e.g.,

to specify an origin of 300 on line 1, type:

0001

$\square$ 300_{EOL}

b. No spaces are permitted on an origin line except before the origin character.

c. An origin line may not contain a line of program. If a line of program appears before an origin character on the same line, the program line will be omitted during conversion. If it appears after, the origin may be interpreted incorrectly.

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- d. Origins may be specified throughout the program. If portions of the program overlap as a result, the resultant binary is generally incorrect.
- e. Conversion is faster if origins referring to the same quarter of memory are entered consecutively in the manuscript; i.e., not interspersed with origins referring to different quarters. This technique is not required, but it saves much tape shuffling during conversion.
- f. Programs with no initial origin will be located at 20.

2.5.2 Comments

- a. Comments are permitted anywhere in the manuscript as long as they occupy a line by themselves.
- b. A comment line must begin with the comment character (L). It cannot begin with a space.
- c. If a comment is included on a line of program, the program line will be omitted during conversion.

2.5.3 Tags

- a. Any program line (i.e., any manuscript line except origins, comments, and equalities) may be tagged. That is, it may be identified by a symbol which, during conversion, will correspond to the actual memory location of the program line.
- b. A tagged line must begin with the tag symbol, #. It may not begin with a space.
- c. Tags are limited to two characters.
 - (1) They must be of the format "number, letter".
 - (2) The numbers are 1 through 7; letters are capitals, A through Z.
 - (3) No spaces are permitted within the tag, e.g., #2A is correct; # 2A is not.
 - (4) Any other format, or any other combination of characters will be called to the typist's attention, (see Error Detection).
- d. No tag terminator is required.
- e. A "number, letter" combination may be used once as a tag (#) if it is not also used as an equality (=).

2.5.4 Symbolic Operation Mnemonics

- a. All first-order 3-letter mnemonics for operation codes are permitted. Substitute mnemonics as defined by chart 4.1 are also permitted.
- b. No spaces are permitted within the mnemonic.

2.5.5 Special Symbols

- a. Bit 7 (the i-bit) is specified symbolically with "i". Typing "i" on a program line causes bit 4 to be set to a 1 during conversion.
- b. Bit 8 (the tape unit bit) is specified symbolically with "u". Typing "u" on a program line causes bit 3 to be set to a 1 during conversion.
- c. The vertical bar (|) is used in the second line of tape instructions to separate QN and BN; e.g., QN = 3 and BN = 45, written "3|45", will be converted to 3045.

(1) Spaces are permitted as indicated by apostrophes:

' 3 ' | ' 45 '

- d. "Present location" is specified symbolically with "p".
- e. The "+" and "-" symbols are used as "plus" and "minus" in relative addressing and assigning the sign of a number; e.g., -567 will be converted to 7210. The "-" symbol is also interpreted as "dash" for some of the meta commands, e.g., RE 52-67.
- f. The equality symbol, =, is used to assign a value to an undefined "number, letter" combination. It is not a tag and it may not be used to assign a location to a tagged line.

(1) Equalities are permitted anywhere in the manuscript as long as they occupy a line by themselves.

(2) The numbers are 1 through 7; letters are capitals, A through Z.

(3) The "number, letter" combination must be on the left of the "=" symbol; the numerical assignment on the right.

(4) No spaces are permitted anywhere on an equality line.

(5) The numerical assignment may not be signed, e.g.,

6G=7774 is legal;

6G= -3 is not.

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(6) A "number, letter" combination may be defined once by an equality (=) if it is not also defined by a tag (#). If a "number, letter" combination is defined more than once, the last definition entered in the manuscript will be the one used during conversion, (see Convert Meta, section 2.6.7).

2.5.6 Numerals

- a. Numerals on any line of manuscript or in any meta command must be octal constants. LAP4 converts incorrectly any numbers containing an 8 or 9.
- b. Spaces are not permitted between the digits of a number, e.g., 7745 is legal; 774 5 is not.

2.5.7 Address Field

- a. Symbolic and relative addressing with any combination of "number, letter" numerals or "p" is permitted, e.g.,

JMP p-5
ADD 6+4K
3C+6-p
-4+7Z
- b. No spaces are permitted within the address field.
- c. Undefined "number, letter" combinations in the address field are assigned the value 0, and the error indicated during conversion, (see Convert Meta 2.6.7) e.g., JMP 3X, when 3X is not defined, will be converted to 6000.
- d. For multiple-defined "number, letter" combinations, LAP4 uses the last one entered in the manuscript for the assignment, regardless of whether it was entered with # or =. The error will be indicated during conversion, (see Convert Meta 2.6.7), e.g., the following are converted as shown:

<u>Location</u>	<u>Manuscript</u>	<u>Conversion</u>
	□100	
100)	#2F ADD 3	2003
101)	JMP 2F+2	6042 (not 6102)
	2F=40	

2.5.8 Spacing

- a. No spaces are required anywhere in a line except as desired by the typist for scope placement.
- b. Spaces may not be inserted:
 - (1) Within tags: (#2 K).
 - (2) Within origins: (□ 270).
 - (3) Within symbolic operation mnemonics: (S TC).
 - (4) Between the digits of a number: (3 45).
 - (5) Within the address field: (3X- 5).
 - (6) Within equalities: (4L =770).
- c. Spaces may be inserted between the tag, operation, index, address, and vertical bar fields of the line, e.g.,

```
#3D STA i 3X
      RDC i u
      2 | 100
```

- d. Lines which begin with either a tag (#) or a comment (L) symbol are automatically positioned at the left of the scope. All other lines appear toward the middle of the scope.

2.5.9 Error Detection

- a. The assembler detects some lines which contain errors while they are being keyed in. These are:
 - (1) Tagged lines which begin with an illegal tag or tag format.
 - (2) Lines which are too long.
 - (3) Lines which contain either a tag or an origin character anywhere except first on the line. This includes comments.
- b. Faulty lines are held on the scope. The typist must hit del which will delete the line; no other key has an effect.
- c. Error detection for faulty meta commands is somewhat different and will be described below.

2.6 META COMMANDS

LAP4 provides 12 meta commands for changing, controlling, and converting manuscript.

- a. Except for the terminator, meta commands are entered exactly as regular manuscript lines. They are displayed with a line number and may be deleted with "del" any time before the terminator is struck.
- b. The meta command terminator is a case shift (CASE) followed by the EOL key; this combination is marked META on the keyboard.
- c. Meta commands are executed when they are entered, and automatically deleted from the manuscript at that time. After a meta command is executed, LAP4 returns to normal input operation, displaying the current line number on the scope. Continue typing.

Two kinds of errors are associated with the meta commands.

- a. Immediately after a meta command is entered with the META key, the tapes churn if the format of the command is correct. If the format is incorrect, LAP4 deletes it from the manuscript, but takes no other action. The absence of tape motion usually indicates a faulty meta command.
- b. Once the command has been accepted, if LAP4 finds that it cannot then be executed, a "NO" appears on the scope. (This does not happen until the tapes have churned awhile and LAP4 has at least tried.) The "NO" remains on the scope until a key (any key) is struck; LAP4 then returns to normal input operation displaying the current line number. The manuscript entered up to this point is still intact.

Meta Command Formats:

- a. Must be at least two letters as specified on chart 4.7. If no numeric parameters follow, any other characters may also be typed: e.g., PACK may be specified with PA, PAC, PACK, PALIMPSEST, etc., as long as the "PA" is present. However, when numeric parameters follow, only two letters are permitted.
- b. Spaces are permitted only between the command and the parameters.

Except for add manuscript, copy, manuscript control, convert manuscripts, and start LAP, commands are effective only for manuscript in the working area of the tape, (see section 2.4).

The twelve meta commands are: remove, insert, pack, display, save manuscript, add manuscript, convert, convert manuscripts, copy, start LAP, start GUIDE, and manuscript control. Their usage and operation are described in the following sections.

2.6.1 RE: RemoveFormat: RE LN, n_{META}or: RE LN-LN+n_{META}

a. Lines may be removed from the manuscript by typing "RE" followed by the line number, LN, (spaces optional) of the first line to be removed. This is followed by a comma and the number of lines (octal) to be removed, or by a "-" and the first line number after the area to be removed, e.g., to remove 5 lines beginning with line 230, when the manuscript presently goes through line 402, type (on line 0403):

0403 RE 230,5_{META}

or

0403 RE 230-235_{META}

When the META character is entered, LAP4 will execute the command; the rest of the manuscript is automatically renumbered, and LAP4 returns to normal input operation by displaying 0376 as the next line number.

b. When a remove includes the last line in the manuscript, any terminating parameter beyond that point will remove the lines, e.g., to remove the last 10 lines of a manuscript which presently ends at line 164, type:

0165 RE 155,10 (or any number greater than 10)_{META}

or

0165 RE 155-165 (or any number greater than 165)_{META}

c. LAP4 responds with a "NO" when a remove requests a line number (as the initial parameter) not contained in the manuscript, e.g., to remove line 20, when the manuscript only goes through line 10.

2.6.2 IN: InsertFormat: IN LN_{META}

EN: End

EN_{META}

a. Lines may be inserted in the manuscript by typing "IN", followed by the line number of the line following the place the inserts are to be put. "IN 30_{META}" means "insert the following before line 30." A 0030 will appear on the scope as the next line number; lines to be inserted are entered at this point just as regular lines. They may be deleted with "del", just

as regular lines, but LAP4 deletes only through line 0030. When all the lines have been entered, type "EN_{META}" (as a separate line). LAP4 will make the inserts and return with the new present line number on the scope, e.g., if 3 lines are to be inserted before the current line 40 in a manuscript which is presently 105 lines long, the following sequence will appear on the scope (one line at a time):

0106	IN 40 _{META}	Type meta command
0040		
0041	EOL	} Enter the 3 lines
0042	EOL	
0043	EOL	
	EN _{META}	End meta command
0111		New line number appears; continue typing.

The commands on lines 106 and 43 are deleted automatically when they are executed.

b. Following the IN command but preceding the EN command, LAP4 will accept no other meta commands. If another meta command is entered, a question mark will appear on the scope on the line with the meta, and LAP4 will wait for the line to be deleted.

c. LAP4 permits the user to insert up to 1 memory quarter of information with one insert command, i.e., approximately 100-110 lines. Should this much be inserted without terminating the command, it will automatically be terminated by LAP4, the inserts will be made, and the new line number will appear on the scope. The user may continue inserting by giving a new insert command.

d. LAP4 will respond with a "NO" when an insert requests a line number not contained in the manuscript, e.g., to insert before line 50, when the manuscript only goes through line 42.

e. LAP4 responds with a "NO" when no lines are inserted, i.e., when a request for an insert is followed immediately by EN_{META}. Striking EOL returns control to regular input at the line number on which the INSERT meta command was typed.

2.6.3 PA: PackFormat: PA_{META}

The meta commands insert, remove, add manuscript, and manuscript control option 2 leave gaps in the manuscript wherever the change or addition is made. When several of these commands are executed, the number of tape blocks occupied by the manuscript can become quite large; the length of time required to execute further commands grows proportionately. Pack condenses the manuscript; it does not, however, change it in any other way. Giving a pack command when no insert, remove, add manuscript, or manuscript control option 2 (section 2.6.12.1) has been executed does nothing (except to make the tapes churn).

2.6.4 DI: DisplayFormat: DI LN,S_{META}

a. This command displays from 1 to 100 (octal) lines of manuscript on the scope. The user may specify initially and during operation of the meta the number of lines, from 1 to 100 (octal), to be displayed on the scope as one frame, and the number of the manuscript line with which the frame will begin. The user may also move the display either forward or backward one frame at a time.

- (1) Initially the parameter S, and during operation a series of octal numbers terminated by S (for size) causes the number of lines specified to be displayed. The octal number must lie in the range of 1 through 100. A number from 1 through 20 causes full size characters to be shown; from 21 through 100, half-size characters. The new size display begins with the same line number as the previous size display.
 - (2) Initially the parameter LN, and during operation a series of octal numbers terminated by L (for line) causes the display to begin the frame with the line number specified; the current size of the display is retained. The number must lie between 1 and the final line number of the manuscript.
 - (3) During operation of the meta, F (for forward) causes the display to be advanced one frame; no advance can be made beyond the last line number.
 - (4) During operation of the meta, B (for backward) causes the display to be backed up one frame; no backward frame change is possible when line 1 is displayed.
- b. Lines are displayed with line number.
- c. To terminate the display, hit EOL. LAP4 returns to normal input operations.
- d. If a request is given to display an unpacked manuscript, LAP4 packs it automatically before displaying it.

- e. All keys other than octal numbers, B, F, L, S, and EOL are ignored. L or S not preceded by octal numbers is ignored; octal numbers followed by any key other than L or S are ignored.
- f. The display disappears from the scope when an octal number is struck, awaiting the terminal L or S.
- g. Octal numbers larger than the allowed upper limit for L or S cause the upper limit to be used. A 0 followed by L or S causes 1 to be used. Octal numbers in excess of 377 may not be used.
- h. Both, either, or none of the parameters L and S may be specified initially. If L is not given, 1 is used; if S is not given, 10 is used. The following are examples of legitimate formats, indicating what L and S values will be in effect for the initial display:

DI META	Line 1, size 10
DI 100,20 META	Line 100, size 20
DI 50 META	Line 50, size 10
DI, 1 META	Line 1, size 1

2.6.5 SM: Save Manuscript

Format: SM META

- a. Manuscript in the working area of the LAP4 tape can be saved at any time in any consecutive blocks on either unit. Saving manuscript via this meta command in the LAP4, GUIDE, or MS file area on the tape is not recommended.
- b. An unpacked manuscript is automatically packed before the SM command is executed.
- c. When the user types "SM META" the following appears on the scope:

SAVE
n BLOCKS
AT BLOCK ?,
UNIT ?

- (1) "n", supplied by LAP4 is the number of blocks occupied by the manuscript; n is never less than 2, because of a control block which accompanies every manuscript.
- (2) The user fills the question marks: he types the block number of the first block where the manuscript is to be put, which replaces the "?" on line 3 above. He there terminates

the line with EOL and types the unit number, which replaces the "?" on line 4, and, finally terminates with a second EOL and the command is executed.

(3) Should deletion seem necessary, hit del and the question mark(s) reappear, one "del" restoring one "?". Type the entry again, (doing any "del"s before the final EOL). If the typing is unacceptable to LAP4, the question mark(s) reappear automatically when the EOLs are struck.

2.6.6 AM: Add Manuscript

Format: AM BN, UN_{META}

Add Manuscript adds a manuscript which has been saved on either tape unit to the manuscript which is in the LAP4 working area. If this command is given while on line 1, the added manuscript will be the only manuscript in the working area. Use of this meta saves typing in short subroutines that the user may want in his program and saves conversion time because the CV meta rather than the CM meta may be used.

Type "AM" followed by the block number (BN), a comma, and the unit number (UN) specifying the present location of the manuscript. Block number must be a number between 0 and 776; unit number must be 0 or 1.

- a. Only manuscripts which have been saved with a save manuscript or through manuscript control can be read with an add manuscript.
- b. After the command is executed, LAP4 returns with the line number changed to the old line number of lines in the added manuscript.
- c. Always pack after several manuscripts have been added to the LAP4 working area in order to eliminate unused space between manuscripts (see chart 4.4).
- d. LAP4 returns with a "NO" when there is no manuscript at the specified block number. Hitting any key at this point causes normal input operation to resume with the manuscript in the working area still intact.
- e. The meta command is ignored if the requested block number is non-numeric.

2.6.7 CV: Convert

Format: CV_{META}

The CV command converts to binary the manuscript in the working area of the tape.

- a. The binary version is in blocks 330-333 of the tape on unit 0 (the system tape) after conversion. Block numbers correspond to memory quarters 0-3 respectively.
- b. After conversion LAP4 returns to normal input, if no tag definition errors are found.
- c. If LAP4 detects tag definition errors during conversion, it brings them to the attention of the user. There are two categories of tag definition errors: undefined tags and multiple-defined tags. Errors in either one or both of these categories are displayed. The displays are as follows: first

MULTIPLE-DEFINED TAGS
NL
NL
etc.

and then,

UNDEFINED TAGS
NL
NL
etc.

There is a maximum of seven number-letter (NL) combinations per page; subsequent pages may be displayed by striking F (forward). Striking B (backward) causes the display of the first page of the first category. F is inoperative if the last page of the last category is being viewed; similarly, B is inoperative on the first page of the first category. Return to LAP4 regular input is accomplished by striking EOL.

- d. No manuscript may contain in excess of 3777 (octal) lines.

2.6.8 CM: Convert Manuscripts

Format: CM_{META}

To convert manuscripts not in the working area of the tape, the command "CM" is used. After the command is given, the following appears on the scope:

CONVERT MANUSCRIPTS AT

- a. Type the block number(s) specifying the location of the beginning of each manuscript to be converted, and separate the block number entries with spaces. The numbers appear on the scope as they are typed; "del" deletes them one at a time. LAP4 deletes nonexistent block numbers as they are typed.

- b. See Convert Meta (2.6.7) for description of tag definition error indications.
- c. No single manuscript converted by this meta may have in excess of 2000 (octal) lines. There is no restriction on the total number of lines in all manuscripts.
- d. The manuscript(s) specified must all be on the tape on unit 0.
- e. Multiple manuscripts are converted together in the order in which they are requested; i.e., they are treated as one longer manuscript. (This has relevance to origins in the manuscripts.)
- f. The manuscript(s) may not be in the working area of the tape. Only manuscript(s) which have been saved with save manuscript or manuscript control may be converted with CM.
- g. As many as eight manuscripts may be selected. When eight have been selected, LAP4 terminates the selection automatically and executes the command. Otherwise:
- h. Terminate the manuscript selection with EOL. LAP4 converts the manuscript(s) and returns to normal input operation. The manuscript in the working area is as it was before the CM command was given.
- i. As with CV, the binary conversion is in blocks 330-333 on unit 0, block numbers corresponding to memory quarters 0-3, respectively.
- j. A "NO" appears if LAP4 finds that any of the blocks specified do not contain the beginning of a manuscript saved by save manuscript or manuscript control. Striking any key causes LAP4 to return to normal input operation. The manuscript in the working area is as it was before the CM command was given.

2.6.9 CP: Copy

Format: CP_{META}

This command permits the user to copy any number of blocks to any place on either unit. (It does not apply only to manuscript.) When the command is given, the following appears on the scope:



- a. Fill in the question marks as indicated, terminating each line entry with EOL. The command is executed when the EOL is struck terminating the sixth line in the display above. Hitting del deletes past entries (see chart 4.8). If LAP4 discovers an illegal entry after the last EOL has been typed, the above display appears again on the scope and the questions must be reanswered.
- b. Since LAP4 can only copy three blocks at a time (because of memory limitations), care should be taken not to overlap the block numbers when requesting copy. Example: Copying 6 blocks from block 550 to block 553 on the same unit does not work. Copying 3 blocks, however, from block 550 to block 551 on the same unit works. (Obviously, if the units are different the copying will be successful.)
- c. After the COPY, LAP4 returns to normal input operation; the manuscript in the working area appears as it was before the command was given.
- d. No more than 777_8 blocks may be copied at one time.

2.6.10 LA: Start LAP

Format: LA_{META}

This command permits the user to restart LAP4 with the working area clear and the first line number 0001 displayed, but without using the switches or GUIDE.

2.6.11 GU: Start GUIDE

Format: GU_{META}

This command permits the user to leave LAP4 and go to GUIDE to do other things, and manuscript is saved in the working area of LAP4. When the user is ready the LAPRTN system command in GUIDE restores LAP4 as it was upon execution of the start GUIDE meta command, (see LAPRTN 3.3.4).

2.6.12 MC: Manuscript Control

Format: MC_{META}

This command allows the user to create files of labeled manuscripts and to move these manuscripts to and from the LAP4 working area by name. A manuscript file is a group of 100 (octal) contiguous tape blocks, beginning with an even hundred numbered blocks, the first of which is reserved as a file control block containing the labels and other necessary information about the manuscripts which reside in the remaining 77 blocks. Files are numbered from 0 through 7, referring to the file control blocks 000, 100, ..., 700. File 2 on unit 0 is called the standard file; this standard file occupies

blocks through 267 (not 277) since LAP4 begins at block 270. If SENSE switch 0 is down during the operation of this meta command, use of the standard file is assumed; if SENSE switch 0 is up, the user is asked to designate file and unit. It is recommended that use be made of the standard file for storing manuscripts of programs that are still in the active debugging and modification stages. For permanent MS files, it is advantageous to use a tape, reserved entirely for such files, mounted on unit 1.

After MC_{META} has been typed, the following appears on the scope:

```
DO ?
0.  RETURN TO LAP
1.  DISPLAY MS INDEX
2.  ADD MS
3.  ENTER MS IN FILE
4.  REMOVE MS FROM FILE
```

The user must supply, via the keyboard, the number (0 through 4) of the desired option; striking EOL causes execution of the specified option. Supplying any character other than 0, 1, 2, 3, or 4, causes this display to be repeated (see chart 4.9 for a summary of the procedure for answering the questions in this and the following displays).

2.6.12.1 Options—A description of the action of each of the options follows:

Option 0. Return to LAP

Control is returned to LAP4 regular input at the line on which MC_{META} was typed.

Option 1. Display MS Index

If SENSE switch 0 is down, the standard file is referenced; if SENSE switch 0 is up, the following appears on the scope:

```
FILE ?
UNIT ?
```

The user must supply the file number (0-7) and the desired unit (0 or 1). The control block of the specified file is referenced and its contents displayed as follows:

```
NO. OF MS IN THIS
FILE IS n

NAME      B      N
XXXXXX   XXX   XX
  ⋮       ⋮     ⋮
  ⋮       ⋮     ⋮
```

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The 6-character name assigned to the MS is displayed together with the number of the tape block (B) which contains the MS control block and the number (N) of tape blocks occupied by the MS. A maximum of four lines is shown per page. Striking the keys F (forward) or B (backward) allows the user to step through the file index display at will. Gaps in the file due to MS removals are not explicitly indicated. EOL causes a return to the MC option display. If no MS has ever been stored in this file, the user is informed that there is:

NO FILE HERE

If a file has been created there, but all the MS have been removed, the display is the same as for an occupied file but with an n of 0 and no entries after the heading. In all cases EOL returns control to the MC option display.

Option 2. Add MS

The proper file should be selected in the same manner as in option 1. The user then is asked to supply the symbolic name under which the requested MS is filed:

MS NAME IS
??????

A search is made of the file control block for a MS with this name; if no match is found, the following appears:

NO SUCH NAME

EOL returns to MC option display. If a match is found, the requested MS is automatically added to the LAP4 working area by the add-manuscript meta command. Control then returns to LAP4 regular input just as in the normal operation of the add-manuscript meta.

Option 3. Enter MS in File

The user is first asked:

FILE MS FROM ?
0. LAP4 WORKING AREA
1. TAPE

If 0 is supplied, it is assumed that the MS occupies tape block 335 and following. If 1 is supplied, the following information is required:

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IN
BLOCK ???
UNIT ?

The block number (leading 0's required) supplied must be the location of the MS control block; the MS must have been saved through either the SM or MC meta commands. The location of the MS now determined, the user is asked to assign a name:

MS NAME IS
??????

This name may be any six keyboard characters, upper or lower case, except EOL, which terminates the answer (CASE is not counted in the six). Then the unit and file in which the MS is to be placed is selected in the same manner as in option 1. The MS name, initial block number, and number of blocks are determined and entered in the file control block; if no file control block exists, one is created. The MS itself then is transferred to the file; if unpacked, it will be packed before filing. Control then is returned to the MC option display. If the name assigned to the MS corresponds to one already in the file, the following appears:

DUPLICATE NAME

EOL returns control to the name request display above, thus allowing the user to change either the name or the file. If, after a search through the file in which both the space available at the end of the existing entries and the gaps left by removals are checked, there is an insufficient number of consecutive blocks to contain the MS being filed, the following appears:

NO ROOM

EOL then returns control to the MC option display. This same display appears if an attempt is made to place a MS in either file 3 or 4 on unit 0 (the LAP4 and GUIDE tape areas).

Option 4. Remove MS from File

The file and unit are selected in the same manner as in option 1. The tape of the MS to be removed is then requested:

REMOVE MS
??????

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After the EOL, the control block of the specified file is updated by having the entry corresponding to the named MS removed. Only the file control block is rewritten; the MS itself is not removed from the file at this time, but may be during the next attempt to enter a MS in this file. Control returns to the MC option display.

If no MS bearing the indicated name is found in the file, display shows that there is:

NO SUCH NAME

EOL returns to MC option display.

CHAPTER 3 GUIDE SYSTEM (A Guide to Binary Programs)

3.1 INTRODUCTION

GUIDE is a system of routines that controls a file of binary programs stored on magnetic tape. The user may retrieve by name and execute any one of the programs in the file. New programs may be added to the file and outdated programs deleted. The GUIDE system also provides for communication with LAP4, the rewinding of tapes and the creation of tapes embodying both the LAP4, and the GUIDE system.

The GUIDE system occupies blocks 400-407 on tape (see chart 4.5). Through GUIDE, the user can build a file of binary programs in blocks 410-477. GUIDE maintains an index of the short titles of the programs to this file along with certain information relevant to the execution of these programs.

Within GUIDE there are seven system commands: INDIS, REWIND, LAPGO, LAPRTN, CAST, FILEBI, and DELETE. These system commands allow the user to select among the operations provided by GUIDE and are in addition to the basic facility to retrieve and execute any program in the file of binary programs maintained by GUIDE. The use of these system commands may be demonstrated by a description of the sequence of steps required to prepare, file, and execute a program with the aid of LAP4 and GUIDE.

The user may wish to begin by copying LAP4 and GUIDE onto a freshly marked tape. This step can be accomplished automatically by executing the system command, CAST. Executing LAPGO transfers control to LAP4 with the working area empty and the line number 0001 displayed on the screen. The manuscript of the program should now be prepared in the usual manner (see sections 2.3 and 2.4). After the manuscript has been converted to a binary program, the user may leave LAP4 and return to GUIDE by use of the GU meta command. FILEBI may be used to enter this binary program in the file maintained by GUIDE and to record information in an index relevant to the retrieval and execution of the program. The contents of this index may be displayed by executing the system command, INDIS. The seven system commands are displayed in addition to the short titles, block number, number of blocks, and starting locations of each of the programs in the file. The index includes all this information for the program just filed so that the program can be read into memory through the toggle switches and started in the usual manner. The user may choose to type the short title of the program on the keyboard and let GUIDE transfer the program into memory automatically. The program can be started automatically by GUIDE or not as the user prefers.

During debugging it may be necessary to return to LAP4 several times to make corrections to the manuscript or to adjust parameters. Execution of LAPRTN returns control to LAP4 with the

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manuscript that was left in the working area available and unchanged. The line number following the last manuscript line is displayed on the screen, and the user may begin typing as usual (see section 2.4). After the changes have been made and the manuscript has again been converted, a corrected version of the binary program can replace the old version in the file. This replacement can be done by toggle switch instructions if no change in the information in the index is required. Otherwise, the outdated binary program can be removed from the index and thereby effectively removed from the file by DELETE. The revised binary program is then filed by use of FILEBI.

Operation of the GUIDE system, like LAP4, requires that tape unit 0 be used. However, another tape that has the GUIDE system in blocks 400-407 can be simultaneously mounted on unit 1; its index examined, binary programs filed in blocks 410-477, and programs retrieved, executed, and deleted all using unit 1. This provides a convenient means for transferring programs by name from a file on one tape to a file on another. Files may be reorganized and programs exchanged among users with ease.

A Teletype is useful for printing listings of manuscripts prepared with LAP4. Several programs that operate a Teletype are included within the file maintained by GUIDE. The programs (KBDTEL, MSPRNT, MSQUIP, OLIST, DISASS, and INPRNT) assume that connections are made to the LINC-8 so that turning on bit 0 of the relay register produces a signal for a mark at the Teletype. Other connections of the Teletype are equally reasonable and the changes in the programs that are required are indicated on chart 4.9.

3.2 GENERAL INFORMATION

3.2.1 Operating Procedure

- a. Mount a system tape on unit 0. In the LEFT SWITCHES, put 0700 (read and check). In the RIGHT SWITCHES, put 3400 (into Q3 from block 400). Raise the DO lever (toggle instruction).
- b. When the tape stops, press the START RS button (bits 10 and 11 in 3400 are ignored so the computer starts at 1400). Bit 0 of the relay register turns on. If a Teletype is connected this prevents it from clattering.
- c. GUIDE requests the 6-letter title of a program and the number of the tape unit on which the program can be found.

EXECUTE THE PROGRAM ???????

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- d. Replace the first six question marks by typing the short title of the program (see chart 4.8). Answer the seventh question mark by typing the tape unit number (0 or 1) and strike EOL. A blank in the seventh position implies unit 0, so that an EOL struck immediately after the name always causes unit 0 to be used.
- e. After the EOL, GUIDE reads the program into memory and starts it.

3.2.2 Precautions

- a. GUIDE reads multiple blocks (maximum of four) of program into consecutive quarters of core storage beginning with the quarter containing the starting location and continuing to the end of the program. If a program block is read into Q3, GUIDE uses registers 1, 2, and 3. If a program block is read into Q0, registers 1, 2, and 3 are altered.
- b. If a program is to be executed from unit 1, the GUIDE system must be present on the tape on unit 1.
- c. To keep the relay register from being changed, replace the contents of location 1407 in GUIDE (block 400, Q3), with a NOP instruction. To alter the bit pattern in the relay register, see chart 4.9.
- d. Care should be exercised if the program to be run uses the toggle switches. Since the program is usually started automatically by GUIDE, failure to set up the switches prior to striking EOL may result in the inadvertent use of the code previously left in these switches, (e.g., 0700, 3400).
- e. A program that must be started manually should have the instruction, HLT, in the starting location. GUIDE retrieves the program, then halts. Raising the RESUME lever starts the program.

3.2.3 Error Indications

- a. If a program is requested and it is not listed in the index, GUIDE informs the user:

IT'S NOT HERE

Strike the EOL key to return to the first display.

- b. If there is no index, the following is displayed:

INDEX MISSING ON UNIT 0

Striking the EOL key halts the computer.

- c. If a program is requested from unit 1 and if there is no index on its tape, the display is:

INDEX MISSING ON UNIT 1

Strike the EOL key to return to the first display.

3.3 SYSTEM COMMANDS

GUIDE responds to seven system commands for filing and deleting programs, for the creation of new system tapes, for communication with LAP4, and for rewinding the tapes. These seven system commands are listed in the index in GUIDE along with any programs that have been filed. Unlike the programs, the system commands cannot be removed from the index. The procedure for executing a system command is the same as that for retrieving any program in the file (see section 3.2 and chart 4.8).

The seven system commands are INDIS, REWIND, LAPGO, LAPRTN, CAST, FILEBI, and DELETE. Their usage and operation are described in the following sections.

3.3.1 INDIS: Display Index

This command displays the short title, block number, number of blocks, and starting location of each program filed by the GUIDE system. After executing the system command, the following is displayed:

NAME	BN	N	SL
INDIS			
REWIND			
LAPGO			
LAPRTN			

Strike F (for forward) to display the next four titles in the index. Strike B (for backward) to display the previous four titles. B is inoperative on the first page and F on the last page.

The first seven entries in the index are the GUIDE system commands. Succeeding entries identify the programs filed by GUIDE and display the short title of the program, the block number of the first quarter of the program (BN), the number of blocks of program (N), and the starting location of the program (SL). Blocks that have been left blank by DELETE are not shown. Strike EOL to return to the first display in GUIDE.

3.3.2 REWIND: Rewind Tape

REWIND or REWIND0 rewinds the tape on unit 0 and halts. Raise the RESUME lever to restart GUIDE.

REWIND1 rewinds the tape on unit 1 and returns to the first display in GUIDE.

3.3.3 LAPGO: Start LAP

This command starts LAP4 with the working area clear and the first line number 0001 displayed. (The unit number is ignored and LAP4 is obtained from unit 0.)

3.3.4 LAPRTN: Return to LAP

This command restores LAP4 to operation as it was after the last execution of one of certain allowable meta commands. The MS remains intact in the LAP4 working area. The unit number is ignored, and the system is restored from unit 0.

LAPRTN can be executed properly only if LAP4 has in the past been in operation and at that time one of the following meta commands was the last operation performed in LAP4:

- a. Guide (GU)
- b. Manuscript Control (MC)
- c. Convert (CV)
- d. Display (DI)

If any additional MS was typed in via regular input after one of these meta commands, that portion of the MS is lost. LAPGO rather than LAPRTN must always be used with a newly CAST tape.

3.3.5 CAST: Create a System Tape

This command copies LAP4 and the GUIDE system from unit 0 to unit 1. After the CAST command has been entered, the following is displayed:

```
MOUNT MARKED TAPE
ON UNIT 1

COPY SYSTEM AND ?
0 CREATE BASIC INDEX
1 KEEP PRESENT INDEX
IN GUIDE ON UNIT 1
```

Option 0 copies the LAP4 and GUIDE systems onto the tape mounted on unit 1. The index in GUIDE lists only the system commands. This option is normally used when the tape on unit 1 has been freshly marked or when it contains no useful programs in the file area.

Option 1 copies the LAP4 and GUIDE systems onto the tape mounted on unit 1 except for the index in GUIDE. The tape block on unit 1 that normally contains this index is examined and if an index is present, it remains unaltered. If no index is present, one is created listing only the system commands. This option is normally used when a block within either the LAP4 or GUIDE system has been inadvertently altered and it is desirable to retain the index and program filed by GUIDE.

CAST automatically returns to the first display in GUIDE when both systems have been copied onto the tape on unit 1.

3.3.6 FILEBI: File a Binary Program

FILEBI files any binary program from either tape onto either tape, and makes it available through GUIDE. After the FILEBI command has been entered, the following is displayed:

```
FILE PROGRAM AT
??????
FROM UNIT ?
TO UNIT ?
```

A program may be filed by short title or by block number.

Short Title: If a program has been filed by FILEBI on one tape, it may be filed on the other tape by entering its short title and answering the other two questions above. FILEBI obtains the location of the program, its starting locations, and its length from the index.

Block Number: Type the number of the tape block which contains the first block of the program. Leading 0's are not required; leading spaces may not be entered. Answer the last two questions, strike EOL, and the following is asked:

THE TITLE IS ??????
THE STARTING LOCATION
IS????
AND IS ? BLOCKS LONG

Assign a unique 6-letter title; give the starting location and the number of blocks. Leading 0's are not required in the starting location.

After the required information has been received, FILEBI searches the index to see if there is enough room for the program in gaps or at the end of the file. Gaps, left by DELETE, are filled if they are of sufficient length. A gap equal in length to the space required is used first. After the program has been filed and the tapes stop, the following is asked:

DO ?
0 RETURNS TO GUIDE
1 DO MORE FILING

Option 0 returns to the first display in GUIDE.

Option 1 returns to the first display in FILEBI.

If the program is more than one block long:

- a. It must be no more than seven blocks in length.
- b. It must be in consecutive blocks.
- c. The starting location must be in the first block.

If the index is needed on unit 1 and if the GUIDE system is not present, the following is displayed:

INDEX MISSING
ON UNIT 1

Strike EOL to return to the option display above. There should be no attempt to file by short title a program within the same file from which it is to be obtained. Such an error is called to the typist's attention. If there is a matching title in the index it is noted and the following displayed:

DUPLICATE TITLE
ASSIGN THE NEW
TITLE ??????

The first character of the short title may not be a blank or an octal number. If it is, FILEBI asks for another title:

BAD TITLE
ASSIGN THE NEW TITLE
??????

If the user does not want to assign a new title, he must return to GUIDE by starting again (see section 3.2) through the console switches.

Block 477 is the last block in the file. When no group of consecutive blocks of sufficient length is available, no filing is done, and the following is displayed:

NO ROOM

Strike EOL to return to the option display above.

3.3.7 DELETE: Delete a Filed Program

DELETE removes any program from the index that has been filed through FILEBI. After the DELETE command has been entered, the following is asked:

DELETE THE PROGRAM
?????? ON UNIT ?

Fill in the first six question marks by typing the short title of the program to be deleted, and answer the next question by typing the unit number.

After the program is removed from the index, the following is asked:

DO ?
 0 RETURN TO GUIDE
 1 DO MORE DELETING
 2 FILE A PROGRAM

Option 0 returns to the first display in GUIDE (see section 3.2).

Option 1 returns to the first display in DELETE.

Option 2 returns to the first display in FILEBI.

If the user attempts to delete a program not in the index, he is told:

IT'S NOT HERE

Strike EOL to return to the option display above.

If an attempt to delete a GUIDE system command is made, the response is:

CAN'T

Strike EOL to return to the option display above.

If a program is to be deleted from unit 1, and if no index is present on unit 1, the following is displayed:

INDEX MISSING
ON UNIT 1

Strike EOL to return to the option display above.

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CHAPTER 4 CHARTS

4.1 ORDER CODE SUMMARY

MSC	0000	----->	HLT	0000
SET	40		ZTA	5
SAM	100		CLR	11
DIS	140		ATR	14
XSK	200		RTA	15
ROL	240		NOP	16
ROR	300		COM	17
SCR	340			
SXL	400	----->	KST	415
SKP	440	----->		
OPR	500		SNS	440
	540		AZE	450
LMB	600		APO	451
UMB	640		LZE	452
MTP	700		IBZ	453
EXC	740	----->	FLO	454
LDA	1000		ZZZ	455
STA	1040			
ADA	1100		RDC	700
ADM	1140		RCG	701
LAM	1200		RDE	702
MUL	1240		MTB	703
LDH	1300		WRC	704
STH	1340		WCG	705
SHD	1400		WRI	706
SAE	1440		CHK	707
SRO	1500			
BCL	1540			
BSE	1600			
BCO	1640			
	1700			
DSC	1740			
ADD	2000			
STC	4000			
JMP	6000			

TYP	514
KBD	515
RSW	516
LSW	517

HLT	0000
ZTA	5
CLR	11
ATR	14
RTA	15
NOP	16
COM	17

KST	415
SNS	440
AZE	450
APO	451
LZE	452
IBZ	453
FLO	454
ZZZ	455

RDC	700
RCG	701
RDE	702
MTB	703
WRC	704
WCG	705
WRI	706
CHK	707

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4.2 LINC/ASCII TELETYPE CODE

This chart presents a comparison between the Teletype code used in LINC operation and the equivalent ASCII code.

LINC Char.	LINC Code	ASCII Code	ASCII Char.	LINC Char.	LINC Code	ASCII Code	ASCII Char.
A	24	301	A	S	46	323	S
B	25	302	B	T	47	324	T
C	26	303	C	U	50	325	U
D	27	304	D	V	51	326	V
E	30	305	E	W	52	327	W
F	31	306	F	X	53	330	X
G	32	307	G	Y	54	331	Y
H	33	310	H	Z	55	332	Z
I	34	311	I	0	00	260	0
J	35	312	J	1	01	261	1
K	36	313	K	2	02	262	2
L	37	314	L	3	03	263	3
M	40	315	M	4	04	264	4
N	41	316	N	5	05	265	5
O	42	317	O	6	06	266	6
P	43	320	P	7	07	267	7
Q	44	321	Q	8	10	270	8
R	45	322	R	9	11	271	9

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LINC Char.	LINC Code	ASCII Code	ASCII Char.	LINC Char.	LINC Code	ASCII Code	ASCII Char.
META	12	212	LINE FEED	Not used	00	242	"
EOL	12	215	RETURN	Not used	00	250	(
Delete	13	377	RUB OUT	Not used	00	251	)
SPACE	14	240	Space	Not used	00	252	*
=	15	275	=	Not used	00	272	:
i	15	246	&	Not used	00	273	;
μ	16	245	%	Not used	00	274	<
p	16	247	'	Not used	00	276	>
,	17	254	,	Not used	00	277	?
-	17	255	-	Not used	00	300	@
.	20	256	.	Not used	00	334	\
+	20	253	+	Not used	00	335	]
⌘	21	244	\$	Not used	00	336	↑
	21	257	/	Not used	00	337	←
[	22	333	[	Not used	00	204	EOT
#	22	243	#	Not used	00	205	W RU
CASE	23	375	ALT MODE	Not used	00	206	RU
Not used	00	241	!	Not used	00	207	BELL

4.3 UTILITY SYSTEM TAPE ALLOCATION

<u>Block</u>	<u>Allocation</u>
000 - 12	Loading routines
13 - 267	Available to user (may be used for MS files)
270 - 327	LAP4 system
330 - 377*	LAP4 working area
400 - 407	GUIDE system
410 - 477	GUIDE file area
500 - 777	Available to user (may be used for MS files)

*LAP4 does not impose an upper limit on the length of a manuscript. Manuscripts of maximum length (4000₈ lines) in unpacked form might exceed the working area assigned above, but the possibility is extremely remote.

LINC-8 UTILITY SYSTEM

4.4 LAP4 TAPE ALLOCATION

<u>Block</u>	<u>Allocation</u>
270	
271	
272	
273	
274	MANUSCRIPT CONTROL meta command
275	
276	
277	
300	Regular input
301	COPY meta command
302	Temporary Storage
303	
304	
305	CV and CM meta commands
306	
307	Reserved block
310	SAVE MANUSCRIPT meta command
311	
312	DISPLAY meta command
313	PACK meta command
314	
315	INSERT meta command
316	ADD MANUSCRIPT meta command
317	REMOVE meta command
320	Pass III
321	
322	Regular input
323	Temporary storage
324	
325	Temporary storage for INSERTED lines
326	Pass I for conversion
327	Pass II for conversion
330	
331	
332	Binary program after conversion
333	
334	Temporary storage
335	Manuscript control block
336 and ff.	Manuscript

LINC-8 UTILITY SYSTEM

4.5 GUIDE TAPE ALLOCATION

<u>Block</u>	<u>Allocation</u>
400	Input control
401	Display index (INDIS)
402	Index of binary program file
403	Questions and answers subroutine
404	File a binary program (FILEBI)
405	Create a system tape (CAST)
406	File a binary program (FILEBI)
407	Delete a filed program (DELETE)
410 - 477	Binary programs

LINC-8 UTILITY SYSTEM

4.6 LAP4 META COMMANDS

Command	Required Format	Information Requested During Operation	Comments
REMOVE	RE LN,n RE LN-LN+n	none	*Removes n lines of MS beginning with line LN
INSERT END	IN LN EN	none	*Allows insertions of lines prior to line LN; insertion terminated by EN
PACK	PA	none	*Removes gaps in MS left by RE, IN, AM, and MC (option 2)
DISPLAY	DI LN,S	none	*Displays MS; F: forward; B: backward; L after octal nos.: LN; S after octal nos.: S
SAVE MANUSCRIPT	SM	unit number; initial block number	*Saves MS in any designated block on either unit
ADD MANUSCRIPT	AM BN,UN	none	Adds MS to working area from any block on either unit
CONVERT	CV	none	*Converts MS
CONVERT MANUSCRIPTS	CM	initial block number(s) on unit 0 of each MS to be converted	Converts manuscripts residing anywhere on unit 0 tape
COPY	CP	number of blocks to be copied; UN and initial BN of places from and to which copy will be made	Copies up to 777 ₈ blocks from either tape to either tape
START LAP	LA	none	Starts LAP4 system
START GUIDE	GU	none	Starts GUIDE system
MANUSCRIPT CONTROL	MC	option number 0-4; various additional information requested by options 1-4	Allows manipulation of MS files; SSW0 down - standard MS file; up - file requested

LN - line number
n - number of lines
s - size of display

BN - block number
UN - unit number

*Operates only on MS in working area

4.7 GUIDE SYSTEM COMMANDS

Command	Information Requested During Operation	Comments
INDIS	none	Displays index
REWIND	none	Rewinds tapes
LAPGO	none	Starts LAP4
LAPRTN	none	Returns to LAP4
CAST	create basic index or retain old index	Creates a systems tape
FILEBI	name or block number of program; if necessary, short title, starting location and number of blocks, units to and from; return option 0 - 1	Files a binary program by name or block number from and onto either unit
DELETE	name and unit number; return options 0 - 2	Deletes a filed program by name from either unit

LINC-8 UTILITY SYSTEM

4.8 SUMMARY OF ANSWERING PROCEDURES FOR Q&A

Status of Display	Result when Key Struck			
	del	EOL	CASE	All others
no questions	inoperative	proceed*	display fades from scope until next character struck; any next character treated as upper case	inoperative
no entries in current question	answers to all previous questions deleted	current question filled completely with blanks (14);	display fades from scope until next character struck; any next character treated as upper case	struck character appears on scope in place of one question mark
partial entry in current question, question marks remaining	answer to current question deleted	remaining question marks filled with blanks (14); proceed*	display fades from scope until next character struck; any next character treated as upper case	struck character appears on scope in place of one question mark
complete entry in current question, no question marks remaining (EOL not yet struck)	answer to current question deleted	proceed*	display fades from scope until next character struck; any next character treated as upper case	inoperative

*Proceed either back to program or to next question, whichever applies.

4.9 PROGRAM MODIFICATIONS REQUIRED FOR TELETYPE CONNECTION *

Teletype Attached to Relay Register		Program Changes					
Bit Number	Marks On	Input Control	MSPRINT and MSQUIP	KBDTEL	OLIST	INPRNT	DISASS
0	1	no change	no change	no change	no change	no change	no change
0	0	1406 CLR	423 COM 424 BCLi 425 7776 ⋮ 442 0000 1400 CLR	54 COM 55 BCLi 56 7776	320 COM 321 NOP 425 BCLi 426 7776	530 COM 531 BCLi 532 7776 ⋮ 547 0000	1221 COM 1222 BCLi 1223 7776
1, 2, 3, 4, or 5	1	1406 ADD 1773 ⋮ 1773 K*	425 ROLn** ⋮ 442 K* 1400 ADD 442	56 ROLn**	425 ROLn**	532 ROLn** ⋮ 547 K*	1223 ROLn**
1, 2, 3, 4, or 5	0	1406 CLR	423 COM 424 BCLi 425 7776 426 ROLn** ⋮ 442 0000 1400 CLR	54 COM 55 BCLi 56 7776 57 ROLn**	320 COM 321 NOP 322 JMP 424 424 BCLi 425 7776 426 ROLn**	530 COM 531 BCLi 532 7776 533 ROLn** ⋮ 547 K*	1221 COM 1222 BCLi 1223 7776 1224 ROLn**

*K is a constant which when loaded into the relay register will cause the Teletype to stop.

**n is the number 1, 2, 3, 4, or 5, depending upon which relay register bits 1-5 are used.

*Classic LINC only

LINC-8 UTILITY SYSTEM

APPENDIX 1

GLOSSARY

Address	A unique 11-bit binary number assigned to each 12-bit binary word (core storage location in LINC-8 memory; allowable range for addresses is $(0000-3777)_8$).
Assembler	A program which translates program statements in a symbolic language closely resembling machine language into machine language.
β	Refers to bits 8-11 of certain LINC-8 instructions which may reference the β -registers (addresses $0001-0017$).
BN	Abbreviation for block number; see Block.
Binary	Used to refer to the aggregate of the machine language instructions generated by the conversion (assembly) of a manuscript by LAP4.
Block	A numbered section of a marked LINC tape capable of retaining 400_8 12-bit binary words; blocks are numbered consecutively from $(000-777)_8$.
Case	The upper leftmost key on the LINC keyboard, used in input to this LINC-8 utility system to cause the system to treat the next struck character as upper case.
Comment	In LAP4, an MS line beginning with the comment character ($\text{\textcircled{C}}$), used by the programmer to illustrate his MS, but ignored by LAP4 during conversion.

LINC-8 UTILITY SYSTEM

GLOSSARY (continued)

Compiler	A program which translates program statements in a symbolic language closely resembling English or mathematics into machine language.
Control Block	See MS control block or file control block.
Control Console	The LINC-8 panel which contains the toggle switches, pushbuttons, levers, rotary switches, and indicator lights; operation of the LINC-8 utility system is initiated via the control console.
Conversion	The assembly process whereby LAP4 translates a program written in a symbolic language into machine language; MS is converted into binary.
Core Storage	The LINC-8 memory.
Delete	To remove a line of MS or an answer to a displayed question in this LINC-8 Utility system, use the del key.
EOL	Abbreviation for end of line; the key used to indicate to the utility system the end of a MS line or the end of an answer to a displayed question.
Equality	An MS line in LAP4 used to assign an absolute numerical value to a tag.
File	Either the file of binary programs maintained by GUIDE or a file of MS created and maintained under the control of the MC meta command in LAP4.

LINC-8 UTILITY SYSTEM

GLOSSARY (continued)

File Control Block	The first block in an MS file; used in LAP4 by the MC meta command to retain titles, block numbers, etc., of filed MS.
Full-size Character	A character displayed on the scope via a 4 x 6 grid pattern, the grid spacing being 4 units between points.
GUIDE	The GUIDE to binary programs; one of the two systems which comprise this LINC-8 utility system; used for the filing and execution of binary programs.
Half-size Character	A character displayed on the scope via a 4 x 6 point grid pattern, the grid spacing being 2 units between points.
i	The i-bit; bit 7 of certain LINC-8 instructions.
Index	Either the index to the GUIDE file of binary programs or the index to an MS file.
Keyboard Codes	The 6-bit codes for the characters on the LINC keyboard; generated in the accumulator upon the execution of a KBD instruction after a key has been struck.
LAP4	LINC-8 Assembly Program 4; one of the two systems which comprise this LINC-8 utility system; used for the creation, conversion, and filing of MS.
LN	Abbreviation for line number; see line.
Line	A string of characters (keyboard codes) in a LAP4 manuscript, last character of which is EOL (or META).
MS	Abbreviation for manuscript; see manuscript.

LINC-8 UTILITY SYSTEM

GLOSSARY (continued)

MS Control Block	The first block of every LAP4 MS, created during regular input of an MS by LAP4 in the working area; contains information about number of lines, number of tape blocks occupied, etc.
MS Line	A line retained by LAP4 as a permanent part of an MS; i.e., program lines, equalities, origins and comments; as opposed to meta commands.
Machine Language	The directly machine-interpretable, i.e., binary, form of the LINC-8 instructions.
Manuscript	A series of one or more program lines, equalities, origins, and comments typed into the LAP4 system and stored on tape.
Marking	The process whereby a virgin tape is readied for use on the LINC-8.
Meta Command	A line not retained by LAP4 as part of an MS; a direct, immediately executed command to LAP4.
Mnemonics	Three-character acronyms or abbreviations for the LINC-8 instructions.
Object Program	The binary generated by conversion of an MS.
Order Code	The LINC-8 instruction repertoire.
Origin	An MS line used to locate sections of a program in core storage at absolute addresses.

LINC-8 UTILITY SYSTEM

GLOSSARY (continued)

p	Keyboard character; interpreted by LAP4, on a program line, as referring to the present location; i.e., the address of the location in which the binary for the current line will reside.
Packing	The process whereby gaps in MS left by the operation of the meta commands RE, IN, AM, or MC are removed.
Palimpsest	A parchment which has been re-used, the earlier writing having been erased.
Pass	In LAP4, a scan of an MS from beginning to end during conversion.
Program	A series of instructions to the LINC-8.
Program Line	An MS line which will cause binary to be generated; i.e., will occupy a location in core storage upon conversion.
Q	Abbreviation for quarter; see quarter.
QN	Abbreviation for quarter number; see quarter.
Q&A	Abbreviation for the Questions and Answers subroutine, used for displays by the GUIDE system commands, convenience programs, and the LAP4 meta commands CP and MC.
Quarter	One fourth of a 1024_{10} word LINC-8 memory bank; consists of 400_8 contiguous 12-bit words.
Regular Input	The section of LAP4 which accepts input from the keyboard of MC lines and meta commands.

LINC-8 UTILITY SYSTEM

GLOSSARY (continued)

S	Abbreviation for size; refers to the number of lines of MS displayed on the scope by the DI meta command.
SSW	Abbreviation for SENSE switch.
Scope	The standard LINC-8 display scope.
Source Program	MS.
Subroutine	A program written to perform some special function; may be entered from another program, to which it will return control upon completion of its operation.
Symbolic Address	A number, letter combination (tag) used to reference a core location, the absolute value of which is assigned by LAP4 during conversion.
Symbolic Operation Code	Mnemonics.
System Tape	A tape which contains the LAP4 and GUIDE systems.
Tag	A number, letter combination used as a symbolic address by LAP4.
Tape Block	See Block.
UN	Abbreviation for unit number; see Unit.
Unit	LINC-8 tape unit 0 (left) or 1 (right).

LINC-8 UTILITY SYSTEM

GLOSSARY (continued)

Utility System	A programming system for the LINC-8 composed of two communicating systems, LAP4 and GUIDE .
Working Area	That section of a system tape used by the LAP4 system for storing MS and the binary converted from MS; occupies blocks 330 and ff.

