A LINC UTILITY SYSTEM

Technical Report No. 1

March 19, 1965

LAP-4

Biomedical Computer Laboratory

Washington University • School of Medicine

St. Louis, Missouri

BIOMEDICAL COMPUTER LABORATORY

WASHINGTON UNIVERSITY SCHOOL OF MEDICINE

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M. D. McDonald
S. R. Davisson
J. R. Cox, Jr.

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Issued: March 19, 1965
Reprinted: Nov. 15, 1965

Preface

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.

M. D. McDonald
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J. R. Cox, Jr.

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INTRODUCTION

This is a reference manual for a utility system for the LINC. The reader is assumed to have a basic familiarity with programming for digital computers, binary and octal number systems, and the LINC order code and control console. All of the programs and systems described herein were written to be executed by a LINC with 1024 words of memory. A few of the routines will test for a double memory and make use of it when available. Three of the programs require for their operation a Teletype attached to the LINC.

This utility system is composed of two independent but communicating systems, LAP4 (LINC Assembly Program 4) and GUIDE (A Guide to Binary Programs). These systems were written to perform useful functions in the two major areas of activity in digital computer programming: the creation and manipulation of symbolic (source) programs and the filing and execution of binary (object) programs. In this utility system a symbolic program takes the form 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 it will take the form of a sequence of coded instructions directly interpretable by the control section of the LINC. 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.

A systems tape, one having both the LAP4 and the GUIDE systems on it, has the following structure:

Blocks 270 - 327 are used for the LAP4 system, i.e., all the routines necessary to perform the various functions ascribed to LAP4.

Blocks 330 - 377 are the LAP4 working area and they 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.

Blocks 400 - 407 are used for the GUIDE system, i.e., all routines necessary to perform the activities attributed to GUIDE.

Blocks 410 - 477 are the GUIDE file area and they serve as storage for the file of binary programs maintained by GUIDE.

Blocks 0 - 77, 100 - 177, 200 - 267, 500 - 577, 600 - 677, 700 - 777 are available, but need not all be used, for files of manuscripts maintained by LAP 4.

The overall tape structure, and a more detailed description of the LAP4 and GUIDE tape areas can be found on pp. 5.4, 5.5, and 5.6.

Properly studied and correctly used the LAP4 and GUIDE Systems can provide the user with hours of boundless joy and even aid in the conduct of profitable research. Attempts to use the systems with only incomplete knowledge may lead to melancholia and despair. The latter possibility may be avoided by adherence to the following syllabus:

Reading. Begin with a careful reading of the introductions to the LAP4 (p. 2) and GUIDE (p. 3) systems. Consult the glossary (p. 6) to become conversant with any unfamiliar terms and abbreviations. Then scan the remainder of the manual with a look at the charts (p. 5) whenever they are mentioned.

Study. Next follow a program of careful study at the LINC console. Begin with the general information on LAP4 (p. 2.1) 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 p. 5.9 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 as do the programs in section 4.

USAGE. Keep this manual nearby whenever you use this utility system. A loose-leaf notebook is recommended. Tabs to identify the sections are helpful and plastic covers for heavily used pages (particularly the charts in section 5) may be required.

LAP4 System

LINC Assembly Program 4

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 the statement of the problem to be solved easier. These three programming methods are called machine language, symbolic language and problem-oriented language and 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. There are two modes in which problem-oriented languages can be implemented on a computer. 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.

LAP4 is an assembly program for the LINC, 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 is often the investigator himself and LAP4 makes it possible for him to prepare programs with the direct and immediate aid of the LINC. The source language is typed directly on the LINC keyboard. The scope displays the current 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.

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

Input of MS. 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 memory as they are typed. When the quarter is filled a block of manuscript is written on tape in the LAP4 working area (see p. 5.5).

Manipulation of MS. 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.

Conversion of MS. Conversion is the actual assembly process whereby assembly language is converted by LAP4 to binary machine language. This process is controlled by two additional meta commands which allow the assembly of a manuscript either in the working area or anywhere on tape unit 0. The LAP4 assembly is a two-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 u bits.

Certain symbolic address definition errors will be detected by LAP4 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.

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.

1. Type in the MS, correcting indicated errors at once by retyping.

2. Display the completed MS and proofread. If a Teletype is available proofreading may be easier from printed copy. Correct all errors found by means of the appropriate meta commands.

3. 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.

4. Convert. Correct in the MS any undefined or multiply-defined addresses and reconvert.

5. Execute the binary program and debug. See the descriptions of the GUIDE system and the Convenience Programs for routines useful in execution and debugging, e.g., pp. 3.2.4, 3.2.6, 4.4, and 4.5.

6. Return to LAP4 to correct any remaining errors.

I. General Information

A. Operating Procedure

1. LAP4 occupies Blocks 270 - 327 of the tape, plus Blocks 330 and following for "working area" (see p. 5.5). The tape must be on unit 0.

2. 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 pp. 3.2.3 and 3.2.4.)

3. Lines of manuscript and meta commands are typed into the computer via the keyboard. LAP4 displays on the scope the information being typed, one line at a time, as it is keyed in.

4. One quarter of the LINC memory is used to collect manuscript. As the quarter is filled, it is saved on the tape beginning in Block 336 of the working area. It takes approximately 110 - 110 (octal) lines of manuscript to fill one block.

B. Manuscript Lines

1. 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.

2. A manuscript line may not exceed 16_{10} struck characters. This includes spaces and case shifts. The terminator may be the 17th character.

3. Manuscript lines are always terminated by striking the "End-of-Line" key, EOL. Lines which are too long will not be accepted by LAP4. (See Error Detection.)

C. Manuscript Line Numbers

1. 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.

2. 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.

D. Deleting

1. Hitting the delete key, "del," will delete 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---
```

2. 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.

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

E. Display Format

1. The display format is as in the above example, one line at a time.
2. All keyboard characters (see pp. 5.2 and 5.3) are displayed except EOL, del, CASE, and META.
3. Characters are displayed as they are struck.

F. Case Shift

1. Some keys on the keyboard have been assigned both upper and lower cases. The characters in the middle of the keys are lower case (see p. 5.2), and LAP4 normally interprets the keyboard as lower case.

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

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

4. LAP4 will discontinue the display after CASE is struck, wait until the following upper case character is struck and then resume the display.

II. Line Format and Symbols

A. Origins

1. Origins must be specified as octal constants, preceded by an origin character, ⊟ , and terminated with an EOL.

   e.g., To specify an origin of 300 on line 1, type
   0001
   ⊟300$_{EOL}$

2. Spaces are not permitted anywhere on an origin line except before the origin character.

3. 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.

4. Origins may be specified throughout the program. If portions of the program overlap as a result, the resultant binary will in general be incorrect.

5. 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.

6. Programs with no initial origin will be located at 20.

B. Comments

1. Comments are permitted anywhere in the manuscript so long as they occupy a line by themselves.

2. A comment line must begin with the comment character ([). It may not begin with a space.

3. If a comment is included on a line of program, the program line will be omitted during conversion.

C. Tags

1. 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.

2. A tagged line must begin with the tag symbol, #. It may not begin with a space.

3. Tags are limited to two characters.

   a. They must be of the format "number, letter."

   b. The numbers are 1 through 7; letters are capitals, A through Z.

   c. No spaces are permitted within the tag, e.g., #2A is correct; # 2A is not.

   d. Any other format, or any other combination of characters will be called to the typist's attention. (See Error Detection.)

4. No tag terminator is required.

5. A "number,letter" combination may be used once as a tag (#) if it is not also used as an equality (=).

D. Symbolic Operation Mnemonics

1. All first-order three letter mnemonics for operation codes are permitted. Substitute mnemonics as defined by the chart on p. 5.1 are also permitted.

2. No spaces are permitted within the mnemonic.

E. Special Symbols

1. Bit 4 (the i-bit) is specified symbolically with "i". Typing "i" on a program line will cause bit 4 to be set to a 1 during conversion.

2. Bit 3 (the tape unit bit) is specified symbolically with "u". Typing "u" on a program line will cause bit 3 to be set to a 1 during conversion.

3. 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.

   a. Spaces are permitted as indicated by apostrophes:

'3' | '45'

4. "Present Location" is specified symbolically with "p".

5. 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.

6. 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.

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

   b. The numbers are 1 through 7; letters are capitals, A through Z.

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

   d. No spaces are permitted anywhere on an equality line.

   e. The numerical assignment may not be signed.

      e.g., 6G=7774 is legal;
      6G=-3 is not.

   f. 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.)

F. Numerals

1. Numerals on any line of manuscript or in any meta command must be octal constants. LAP4 will convert incorrectly any numbers containing an 8 or 9.

2. Spaces are not permitted between the digits of a number, e.g., 7745 is legal; 774 5 is not.

G. Address Field

1. 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

2. No spaces are permitted within the address field.

3. Undefined "number, letter" combinations in the address field are assigned the value zero, and the error indicated during conversion. (See CONVERT Meta.)

   e.g., JMP 3X, when 3X is not defined, will be converted to 6000.

4. For multiply-defined "number, letter" combinations, LAP4 will use 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.)

   e.g., The following will be converted as shown:

Location	Manuscript	Conversion
	⊟ 100	
100)	#2F ADD 3	2003
101)	JMP 2F+2	6042 (NOT 6102)
	2F=40	

H. Spacing

1. No spaces are required anywhere in a line except as desired by the typist for scope placement.

2. Spaces may not be inserted:

   a. Within tags: (#2 K).
   b. Within origins: (⊟ 270).
   c. Within symbolic operation mnemonics: (S TC).
   d. Between the digits of a number: (3 45).
   e. Within the address field: (3X- 5).
   f. Within equalities: (4L =770).

3. 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
```

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

I. Error Detection

1. Some lines which contain errors are detected by the assembler while they are being keyed in. These are:

   a. Tagged lines which begin with an illegal tag or tag format.

   b. Lines which are too long.

   c. Lines which contain either a tag or an origin character anywhere except first on the line. This includes comments.

2. Faulty lines are held on the scope. The typist must hit "del" which will delete the line; no other key will have an effect.

3. Error detection for faulty meta commands is somewhat different and will be described below. (See p. 2.3.).

III. Meta Commands

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

1. 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.

2. The meta command terminator is a Case Shift (CASE) followed by the EOL key; this combination is marked META on the keyboard.

3. 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.

B. Errors: There are two kinds associated with the meta commands.

1. Immediately after a meta command is entered with the META key, the tapes will churn if the format of the command is correct. If the format is incorrect, LAP4 will delete it from the manuscript, but take no other action. The absence of tape motion may be taken as an indication of a faulty meta command.

2. Once the command has been accepted, if LAP4 finds that it cannot then be executed, a "NO" will appear on the scope. (This does not happen until the tapes have churned a while and LAP4 has at least tried.) The "NO" will remain on the scope until a key (any key) is struck; LAP4 will return to normal input operation displaying the current line number. The manuscript entered up to this point is still intact.

C. Formats

1. Meta commands must be at least two letters as specified on p. 5.7. If no numeric parameters follow, any other characters may also be typed: e.g., "PACK" may be specified with PA, PAC, PACK, PALIMPSEST, etc., so long as the "PA" is present. However, when numeric parameters follow, only two letters are permitted.

2. Spaces are permitted only between the command and the parameters.

D. 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 p. 2.1).

E. 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 beginning on pages 2.3.1 through 2.3.12.

1. REMOVE

Format: RE LN,n_{META}

or: RE LN-LN+n_{META} RE

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 a 0376 as the next line number.

b. When a REMOVE includes the last line in the manuscript, any terminating parameter beyond that point will suffice to 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 will respond 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. INSERT

END

Format: IN LN_{META}

EN_{META}

IN EN

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 will delete 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		
	.....EOL	Enter the 3 lines
0041		
	.....EOL	
0042		
	.....EOL	
0043		
	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 will respond with a "NO" when no lines are inserted, i.e., when a request for an insert is followed immediately by EN_{META}. Striking EOL will return control to regular input at the line number on which the INSERT meta command was typed.

3. PACK

Format: 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 will condense 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 has been executed does nothing (except to make the tapes churn).

4. DISPLAY Format: DI LN,S_{META}

a. This command will display 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) will cause 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 will cause full size characters to be shown; from 21 through 100, half-size characters. The new size display will begin 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) will cause the display to begin the frame with the line number specified; the current size of the display will be retained. The number must lie between 1 and the final line number of the manuscript.

3) During operation of the meta, "F" (for forward) will cause 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) will cause 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 will return to normal input operations.

d. If a request is given to display an unpacked manuscript, LAP4 will pack it automatically before displaying it.

e. All keys other than octal numbers, B, F, L, S, and EOL will be ignored. L or S not preceded by octal numbers will be ignored; octal numbers followed by any key other than L or S will be ignored.

f. The display will disappear 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 will cause the upper limit to be used. A zero followed by L or S will cause 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

5. 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; because of a control block which accompanies every manuscript n is never less than 2.

2) The question marks are to be filled in by the user: type the block number of the first block where you want the manuscript to be put. This will replace the "?" on line 3 above. Terminate the line with EOL and type the unit number. This will replace the "?" on line 4 above. Terminate finally with a second EOL and the command will be executed.

3) If you don't like what you typed, hit "del" and the question mark(s) will reappear. One "del" restores one "?" Type the entry again. (Do any "del"s before the final EOL.) If LAP4 doesn't like what you typed, the question mark(s) will reappear automatically when the EOLs are struck.

6. ADD MANUSCRIPT Format AM BN,UN_{META}

ADD MANUSCRIPT will add 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 will save typing in short subroutines that you may want in your program and will save 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 will return with the line number changed to the old line number plus the 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 p. 5.5).

d. LAP4 will return with a "NO" when there is no manuscript at the specified block number. Hitting a key (any key) at this point will return to normal input operation with the manuscript in the working area still intact.

e. The meta command will be ignored if the requested block number is non-numeric.

7. CONVERT

Format: CV_{META}

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

a. The binary version will be in blocks 330 - 333 of the tape on unit 0 (the systems tape) after conversion. Block numbers correspond to memory quarters 0 - 3 respectively.

b. After conversion LAP4 will return to normal input, if no tag definition errors were found.

c. If tag definition errors were detected by LAP4 during conversion, these will be brought to the attention of the user. There are two categories of tag definition errors: undefined tags and multiply defined tags; errors in either one or both of these categories will be displayed. The displays are as follows: first

```
MULTIPLY-DEFINED TAGS

NL
NL

 etc.
```

and then,

```
UNDEFINED TAGS

NL
NL

 etc.
```

There are a maximum of 7 numbers, letter (NL) combinations per page; subsequent pages may be displayed by striking F (Forward). Striking B (Backward) will cause the display of the first page of the first category. F will be inoperative if the last page of the last category is being viewed; similarly, B will be 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.

8. 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 will appear on the scope:

```
CONVERT
MANUSCRIPTS AT
```

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

b. See CONVERT meta (p. 2.3.7) 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 will terminate the selection automatically and execute the command. Otherwise:

h. Terminate the manuscript selection with EOL. LAP4 will convert the manuscript(s) and return to normal input operation. The manuscript in the working area will be as it was before the CM command was given.

i. As with CV, the binary conversion will be in blocks 330 - 333 on unit 0, block numbers corresponding to memory quarters 0 - 3, respectively.

j. A "NO" will appear if LAP4 finds that any of the blocks specified does not contain the beginning of a manuscript saved by SAVE MANUSCRIPT or MANUSCRIPT CONTROL. Striking any key will cause LAP4 to return to normal input operation. The manuscript in the working area will be as it was before the CM command was given.

9. 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:

COPY	
??? BLOCKS	Number of blocks to move
FROM BLOCK ???	Present location
UNIT ?	
TO BLOCK ???	Requested location
UNIT ?	

a. Fill in the question marks as indicated, terminating each line entry with EOL. The command will be executed when the EOL is struck terminating the sixth line in the display above. Hitting "del" will delete past entries (see p. 5.9). If LAP4 discovers an illegal entry after the last EOL has been typed, the above display will appear again on the scope and the questions must be reanswered.

b. Since LAP4 can only copy 3 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 will not work. Copying 3 blocks, however, from block 550 to block 551 on the same unit will work. (Obviously, if the units are different the copying will be successful.)

c. After the COPY, LAP4 will return to normal input operation; the manuscript in the working area will be as it was before the command was given.

d. No more than 777_8 blocks may be copied at one time.

10. 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.

GU

11. START GUIDE

Format: GU_{META}

This command permits the user to leave LAP4 and go to GUIDE to do other things. Manuscript will be saved in the working area of LAP4. When the user is ready the LAPRIN system command in GUIDE will restore LAP4 as it was when the START GUIDE meta command was executed. (See p. 3.2.4.)

12. 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 defined to be a group of 100 (octal) contiguous tape blocks, beginning with an even hundred numbered block, 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 at blocks 000, 100, ... , 700. File 2 on unit 0 will be 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 will be assumed; if sense switch 0 is up, the user will be 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 has been found advantageous to utilize a tape, reserved entirely for such files, mounted on unit 1.

After MC_{META} has been typed, the following will appear 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 will cause execution of the specified option. Supplying any character other than 0, 1, 2, 3, or 4 will cause this display to be repeated (see p. 5.9 for a summary of the procedure for answering the questions in this and the following displays).

A description of the action of each of the options follows:

0. RETURN TO LAP

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

1. DISPLAY MS INDEX

If sense switch 0 is down, the standard file will be referenced; if sense switch 0 is up, the following will appear 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 will be referenced and its contents displayed as follows:

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

 NAME      B      N
XXXXXX    XXX    XX
  :        :      :
  :        :      :
```

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 (for forward) or B (for 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 will cause a return to the MC option display. If no MS had ever been stored in this file, the user will be informed that there is

```
NO FILE HERE
```

If a file had been created there, but all the MS had been removed, the display will be 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.

2. ADD MS

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

```
MS NAME IS
??????
```

A search will be 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 will automatically be added to the LAP4 working area by means of the ADD MANUSCRIPT meta command (see p. 2.3.6). Control will return to LAP4 regular input just as in the normal operation of the ADD MANUSCRIPT meta.

3. ENTER MS IN FILE

The user will first be asked:

```
FILE MS FROM ?
0.  LAP WORKING AREA
1.  TAPE
```

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

```
IN
BLOCK ???
UNIT ?
```

The block number (leading zeros 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 will be 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 should be selected in the same manner as in option 1. The MS name, initial block number, and number of blocks will be determined and entered in the file control block; if no file control block exists, one will be created. The MS itself will then be transferred to the file; if it is unpacked, it will be packed before it is filed. Control will then be returned to the MC option display. If the name assigned to the MS corresponds to one already in the file, the following will appear:

```
DUPLICATE NAME
```

EOL will return 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 will appear:

```
NO ROOM
```

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

4. REMOVE MS FROM FILE

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

```
REMOVE MS
??????
```

After the EOL, the control block of the specified file will be 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, the user is shown that there is:

NO SUCH NAME

EOL returns to MC option display.

GUIDE SYSTEM

A Guide to Binary Programs

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 systems.

The GUIDE system occupies Blocks 400 - 407 on tape (see p. 5.6). Through the use of GUIDE the user may build a file of binary programs in Blocks 410 - 477. GUIDE maintains an index of the short titles of the programs in 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 options 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 will transfer 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 p. 2.1). 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 enter in an index information 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.

Of course, the index will include all this information for the program just filed so that the program can be read into memory by means of the toggle switches and started in the usual manner. The user may often prefer 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 will return control to LAP4 with the manuscript that was left in the working area available and unchanged. The line number following the last manuscript line will be displayed on the screen and the user may begin typing as usual (see p. 2.1). 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 means of 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 machine is useful for printing listings of manuscripts prepared with LAP4. Several programs that operate a Teletype machine 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 so that turning on bit 0 of the relay register produces a signal for a mark at the Teletype machine. Other connections of the Teletype are equally reasonable and the changes in the programs that are required are indicated (see p. 5.10).

I. General Information

A. Operating Procedure

1. Mount a systems 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).

2. 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 will turn on.

   If a Teletype is connected (p. 3.0.1) this prevents it from clattering.

3. GUIDE will ask for the six-letter title of a program and the number of the tape unit on which the program can be found.

   ```
   EXECUTE THE PROGRAM
   ???????
   ```

4. Replace the first six question marks by typing the short title of the program (see p. 5.9).

   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 will always cause unit 0 to be used.

5. After the EOL, GUIDE will read the program into memory and start it.

B. Precautions

1. GUIDE will read 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, registers 1, 2, and 3 will be used by GUIDE. If a program block has been read into Q0, registers 1, 2, and 3 will be altered.

2. If a program is to be executed from unit 1, the GUIDE system must be present on the tape on unit 1.

3. 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 p. 5.10.

4. 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).

5. A program that must be started manually should have the instruction, HLT, in the starting location. GUIDE will retrieve the program, then halt. Raising the "RESUME" lever will start the program.

C. Error Indications

1. If a program is requested and it is not listed in the index, GUIDE will tell you:

```
IT'S NOT HERE
```

Strike the EOL key to return to the first display.

2. If there is no index, the following will be displayed:

```
INDEX MISSING
ON UNIT 0
```

Striking the EOL key will halt the computer.

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

```
INDEX MISSING
ON UNIT 1
```

Strike the EOL key to return to the first display.

II. System Commands

A. GUIDE responds to seven system commands for filing and deleting programs, for the creation of new systems tapes, for communication with LAP4 and for rewinding the tapes.

1. 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.

2. The procedure for executing a system command is the same as that for retrieving any program in the file (see pp. 3.1 and 5.9).

B. The seven system commands are INDIS, REWIND, LAPGO, LAPRTN, CAST, FILEBI and DELETE. Their usage and operation are described in the following sections (pp. 3.2.1 through 3.2.7).

1. INDIS: Display Index

This command will display the short title, the block number, the number of blocks, and starting location of each program filed by the GUIDE system.

After executing the system command, the following will be 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" will be inoperative on the first page as will "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 will have displayed the short title of the program, the block number of the first quarter 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 will not be shown. Strike EOL to return to the first display in GUIDE.

2. REWIND: Rewind Tape

REWIND or REWIND0 will rewind the tape on unit 0 and halt. Raise the "RESUME" lever to restart GUIDE.

REWIND1 will rewind the tape on unit 1 and return to the first display in GUIDE.

3. LAPGO: Start LAP

This command will start LAP4 with the working area clear and the first line number "0001", displayed.

(The unit number will be ignored and LAP4 will be obtained from unit 0.)

4. LAPRTN: Return to LAP

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

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

1) GUIDE (GU)
2) MANUSCRIPT CONTROL (MC)
3) CONVERT (CV)
4) DISPLAY (DI)

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

LAPRTN may of course be attempted at any time under the pressure of desperation; and, if your penates be willing, some good may come of it.

5. CAST: Create A Systems Tape

This command will copy LAP4 and the Guide system from unit 0 to unit 1. After the CAST command has been entered, the following will be 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 will copy the LAP4 and GUIDE systems onto the tape mounted on unit 1. The index in GUIDE will list 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 will copy 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 will be examined and if an index is present it will be left unaltered. If no index is present, one will be 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 programs filed by GUIDE.

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

6. FILEBI: File a Binary Program

FILEBI will file any binary program from either tape onto either tape, and make it available through GUIDE.

After the FILEBI command has been entered, the following will be 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 will obtain the location of the program, its starting location, and its length from the index.

Block Number: Type the number of the tape block which contains the first block of the program. Leading zeros are not required; leading spaces may not be entered.

Answer the last two questions, strike EOL, and the following will be asked:

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

Assign a unique six-letter title; give the starting location and the number of blocks. Leading zeros are not required in the starting location.

After the required information has been received, FILEBI will search 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 will be filled

if they are of sufficient length. A gap equal in length to the space required will be used first. After the program has been filed and the tapes stop, the following will be asked:

```
DO ?
0 RETURN TO GUIDE
1 DO MORE FILING
```

Option 0 will return to the first display in GUIDE.
Option 1 will return to the first display in FILEBI.

If the program is more than one block long:

1) it must be no more than seven blocks in length.
2) it must be in consecutive blocks
3) 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 will be displayed:

```
INDEX MISSING
ON UNIT 1
```

Strike EOL to return to the option display above.

Of course, 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 will be called to the typist's attention.

If there is a matching title in the index it will be 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 will ask for another title:

```
BAD TITLE

ASSIGN THE NEW TITLE
??????
```

If you do not want to assign a new title you must return to GUIDE by starting again (see p. 3.1) 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 will be done, and the following will be displayed:

```
NO ROOM
```

Strike EOL to return to the option display above (p. 3.2.6.1).

7. DELETE: Delete a Filed Program

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

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

Fill in the first six question marks by typing the short title of the program to be deleted.

Answer the next question by typing the unit number.

After the program is removed from the index the following will be asked:

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

Option 0 will return to the first display in GUIDE (p. 3.1).
Option 1 will return to the first display above.
Option 2 will return to the first display in FILEBI (p. 3.2.6).

If you attempt to delete a program not in the index, you will be 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 will be

```
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 will be displayed:

```
INDEX MISSING
ON UNIT 1
```

Strike EOL to return to the option display above.

CONVENIENCE PROGRAMS

The following convenience programs have been found to be generally helpful in the operation of the LINC. Each is independent of the others, but they all use the Q&A Subroutine in GUIDE. The author's initials can be found in the upper right-hand corner of the page.

They are: Sharon R. Davisson
Michael D. McDonald
Severo M. Ornstein

Title MARK: Mark and Check a Tape (SMO)

Abstract This program marks virgin tape for use by the LINC. After marking, the tape will begin with a short end zone and end with a long end zone. There are two extra check marks at the end of each tape block.

Usage

1. Check the mark clock. It should be set as precisely as possible at 10 μs.
2. Degauss the tape.
3. If the tape is new, manually run it across the head a few times to align it on the reels.
4. Clean the tape heads.
5. Mount a systems tape on unit 0.
6. Start GUIDE (see p. 3.1).
7. Request the MARK program.
8. The following will then be displayed:

```
ALLOW UNIT 0
TO REWIND, THEN
MOUNT VIRGIN TAPE
ON UNIT 1,
AND PRESS MARK BUTTON
```

9. Allow the tape on unit 0 to rewind and mount the tape to be marked on unit 1. Wind about 6" of the tape onto the left-hand hub (about one turn of the reel).
10. Press the "MARK" button.
11. When the program halts, manually rewind the tape onto the right-hand hub to get the tape beyond the right-hand end zone. This is accomplished by pressing the right-hand pushbutton for about five seconds.
12. Raise the "RESUME" lever.

If the tape has been marked, written upon, and checked properly, the following will be displayed:

```
GOOD TAPE
EOL FOR GUIDE
```

If you are finished marking tapes, remount the systems tape on unit 0 and strike EOL. The program will return to the first display in GUIDE.

If you wish to mark another tape, follow steps 2 through 4 and 9 through 12 above.

If there has been a failure in the marking process, the following will be displayed:

```
CHECK FAILURE
```

Start over at step 1.

Title COPY: Copy Tape (MDM)

Abstract By means of COPY, any number of tape blocks from 1 to 777 (octal) may be copied from either tape onto either tape.

Usage Except for entry (requesting COPY from GUIDE) and exit (return to GUIDE), this program functions exactly as the CP meta command in LAP4. (See p. 2.3.9 for full description.)

It has been filed under GUIDE for convenience.

This program tests for a double memory and uses Q4 - Q7 if more than three blocks are copied.

Title KBDTEL: Keyboard Teletype (MDM)

Abstract This program allows the user to print via the LINC keyboard on a Teletype machine attached to the LINC. Control may be transferred automatically to MSPRNT.

Usage After this program is put into execution by GUIDE, it will pause waiting for a key to be struck; each key (including upper case characters) will cause the corresponding Teletype character to be printed. EOL will cause a carriage return and line feed. Striking del will cause the MSPRNT program to be executed automatically. See p. 4.4 for information on the usage of MSPRNT.

To change the pattern entering the relay register, see p. 5.10.

Title MSPRNT: Manuscript Print (MDM)

Abstract This program allows the user to obtain a printed copy of a program manuscript by means of a Teletype machine attached to the LINC (see p. 3.0.1). The MS to be printed may be stored in either the LAP4 working area or any MS file. Sense switches control the printing of the octal equivalents of the instructions, page headings, pauses, and starting line. Only a packed MS can be printed with the program.

Usage All six sense switches are examined by this program; their functions are summarized below:

SSW 0 - down: no action.
up: pause at the end of each page until SSW 0 is lowered.

SSW 1 - down: no action.
up: print, in a column to the right of the MS line, the octal equivalents of those MS lines which generated binary upon conversion, i.e., program lines.

SSW 2 - down: no action.
up: print, in the upper right-hand section, a heading on the tope of each page; this heading will be the first line of MS.

SSW 3 - down: no action.
up: start printing of MS with the MS line number which is set in the right switches on the console.

SSW 4 - down: no action.
up: pause at the end of the current line until SSW 4 is lowered.

SSW 5 - down: MS is retrieved from the LAP4 working area (blocks 335 ff.) and the binary if required, is referenced in the LAP4 area (blocks 330 - 333).
up: MS must reside in one of the MS files; binary may be anywhere on tape.

Switches 0, 1, 2 and 4 may be reset during program operation. Switches 3 and 5 must be set before the program is started. Once the program is underway the positions of switches 3 and 5 have no further effect. If switch 5 is up when the program begins, the location of the MS in a file must be supplied by the user:

```
MS NAME IS ??????
IN FILE ?
UNIT ?
```

The six-character name under which the MS is filed, the MS file number and unit in which it may be found must be typed in (see p. 2.3.12). If SSW 1 is up, the location of the binary will also be requested:

```
BINARY AT BLOCK ???
UNIT ?
FOR MEMORY QUARTER ?
```

The binary must be stored in consecutive blocks which correspond to consecutive memory quarters; the location of the first block of binary, the unit number and the memory quarter for which that block is intended must be entered.

If no MS with the given name is found, the user will be told:

```
NO SUCH NAME
```

If the designated file does not exist, the comment will be made:

```
NO FILE HERE
```

EOL struck after either of these two error indications will cause a return to the initial display in GUIDE.

After the MS and binary have been located, the printing will commence. Each page will contain 100_8 lines, except the first which has 77_8. The first column is the octal location in memory, second the MS line number, third the MS line, and fourth, if requested, the octal equivalent of the binary. Initially, enough paper will be ejected so that any printing that remained in the Teletype may be torn off; likewise, ejection will occur at the end of each page. If the location of the binary program has not been assigned and if SSW 1 is raised after printing has commenced, the binary to be listed in the fourth column will always be obtained from the LAP4 area (blocks 330 - 333).

At the completion of printing, the program will halt; raising the "RESUME" lever will return control to GUIDE.

This program may not be manually restarted; it must always be started by GUIDE.

To change the pattern entering the relay register, see p. 5.10.

Title MSQUIP: Quick Manuscript Print (MDM)

Abstract This program prints a copy of a program manuscript on a Teletype machine attached to the LINC (see p. 3.0.1); printing is faster than by MSPRNT. Only a packed MS can be printed by this program.

Usage This program operates in exactly the same manner as MSPRNT (see p. 4.4) with the following exceptions:

1) Horizontal spacing between columns of information is reduced to 1 space.

2) Vertical spacing after each page is eliminated.

3) Sense switches 0 and 2 are ignored.

The starting line option (SSW 3) of this program produces fast partial program listings that are particularly helpful during debugging.

This program may not be manually restarted; it must always be started by GUIDE.

To change the pattern entering the relay register, see p. 5.10.

Title LOADER: Loader for Octal and Decimal Integers (SRD)

Abstract This program accepts octal or decimal integers (positive or negative) from the keyboard. The integers are stored in successive locations following an arbitrary origin. The completed table of integers is then stored on tape.

Usage After the program is put into execution by GUIDE, the following will be asked:

```
STORE DATA IN
BLOCK ???
STARTING IN
LOCATION ????
```

Answer the questions and set the sense switches as desired.

SSW 0 - down: octal data accepted.
up: decimal data accepted.

Data may be alternately octal or decimal, depending upon SSW 0 when the EOL key is struck after each datum.

SSW 1 - down: positive or negative numbers are accepted. Five spaces are allowed for each data word. The first character must be the sign + or -. The display is:

```
XXXX
    ?????
```

up: positive numbers only are accepted. Four spaces are allowed for each data word. The numbers are assumed to be positive. The display is:

```
XXXX
    ????
```

XXXX is the location in which the integer is to be stored. Leading zeros are not required in any of the fields.

When the data have been entered, type in END and strike the EOL key.

The program will store the data in the requested tape block on unit 0 and return to the first display in GUIDE.

The range for decimal numbers is -2047 to +2047.
The range for signed octal numbers is -3777 to +3777.
The range for positive unsigned octal numbers is 0 to 7777.

Title OSCOPE: Oscilloscope Surrogate (MDM)

Abstract This program will display on the scope the signal samples from a designated one of the 16 input channels, 256 consecutively doubly displayed points at a time. This continuous display may be frozen at any time, and while frozen the current 256 points may, at the user's option, be written on tape either temporarily in block 377 on unit 0 or permanently in the next of a series of designated consecutive blocks on unit 1. The channel sample interval is specified by the user in microseconds and may be any decimal integer multiple of 40 from 40 to 2040. Once sampling has begun, the user may transfer control either back to the beginning of OSCOPE or to GUIDE as the mood strikes him.

Usage The first information requested will be:

```
DATA ON CHANNEL ??
TAKE SAMPLES EVERY
????  SEC
```

The channel number is to be an octal number from 0 through 17 and the sample interval a decimal number from 40 through 2040. After the final EOL, the following is asked:

```
SAMPLES EVERY nnnn
 SEC

DO ?
0. SAVE CURVE IN
TEMP BLOCK
1. SAVE CURVE IN
PERM BLOCK
```

Where "nnnn" is the sample interval (in decimal) quantized to the nearest multiple of 40 above or equal to the interval requested. If option 0 is specified, sampling begins immediately; the selection of option 1 causes the following display:

```
STARTING AT BLOCK ???
ON UNIT 1
```

The user must supply the number of a block that will be the first in a series of blocks in which data will be written.

Leading zeros are not required in answering any of the displayed questions.

The program will begin sampling and displaying, and the sense switches become operative in the following manner:

SSW 0 - down: display continuously.

up: freeze the waveform.

SSW 1 - down: no action.

up: return to the beginning of OSCOPE.

SSW 2 - down: no action.

up: if SSW 0 is up, save the curve in the next permanent block on unit 1 (if no initial permanent block was specified, block 700 will be assumed); if SSW 0 is down, no action.

SSW 3 - down: no action.

up: if SSW 0 is up, save the curve in block 377 on unit 0; if SSW 0 is down, no action.

SSW 4 - down: no action.

up: return to GUIDE.

Once the curve has been saved, SSW 2 and 3 will be inoperative until after SSW 0 has been switched down.

Title KNOBS: Display Potentiometer Settings (SRD)

Abstract This program will display the settings of the eight potentiometers (0-7). New values will be displayed as the settings of the potentiometers are changed.

Usage After the program is put into execution by GUIDE, the following will be displayed:

0 ±XXX	2 ±XXX	4 ±XXX	6 ±XXX
1 ±XXX	3 ±XXX	5 ±XXX	7 ±XXX

In all cases, ±XXX is the potentiometer setting.

Strike the EOL key to return to the first display in GUIDE.

Title OLIST: Octal Listing (MDM)

Abstract This program prints in octal the contents of one block of tape on a Teletype machine attached to the LINC (see p. 3.0.1).

Usage The program must first be supplied with the location of the information to be printed:

```
BLOCK ???
UNIT ?
QUARTER ?
```

The memory quarter number is that for which the data are intended. The final EOL will cause the proper block to be obtained and printing to begin.

Initially, enough paper will be ejected so that any printing that remained in the machine may be torn off.

The printing will be in four pairs of columns. The left column in each pair will be the octal machine location. The right column in each pair will be the octal contents of that location.

There will be 100_8 consecutive locations in each column.

Sense switches 1, 2, 3, and 4 inhibit the printing of pairs of columns 1 through 4, numbered on the page from left to right. If a sense switch is up, printing of the corresponding columns will be inhibited and any remaining columns will be left justified on the page so that the speed of printing will be maximized.

When the printing of data is terminated the paper will be spaced up and the program will return according to SSW 0.

SSW 0 - down: return to GUIDE.
up: restart OLIST

The printing of data may be terminated before the quarter is completed by raising all four switches, 1 - 4.

To change the pattern entering the relay register, see p. 5.10.

Title DISASS: Binary to MS Disassembler (MDM)

Abstract By use of this program, a printed copy may be obtained on a Teletype machine connected to the LINC via bit 0 of the relay register, of a manuscript, i.e., symbolic instructions, which corresponds to a specified binary program.

Usage Initially, enough paper will be ejected from the Teletype so that any printing which remained in it may be torn off; likewise, ejection will occur at the end of each page.

Information concerning the binary program to be disassembled will be requested:

```
BINARY AT
BLOCK ???
UNIT ?
FOR QUARTER ?
NO. OF BLOCKS IS ?
```

The number of the tape block (leading zeros are not required) and unit on which the binary program resides must be supplied; the number of blocks given must refer to consecutive tape blocks beginning with the block number specified; the quarter number must likewise refer to this initial block, with subsequent tape blocks corresponding to contiguous higher quarters. After the final EOL, the printing will commence, 100 (octal) lines per page, 3 columns across. The leftmost column will be the octal core location, next its octal contents and finally the disassembled line.

The results are controlled by the sense switches 0, 1, 2, and 3 as follows:

SSW 0 - down: no action

up: pause at the end of each page, resume when SSW 0 is returned to down position.

SSW 1 - down: no action.

up: relativize addresses (see SSW 3 below).

SSW 2 - down: interpret each line as an instruction.

up: pause before disassembly of current line and await keyboard information on proper way in which to interpret the line; accept 1 of the following keys -

I - interpret line as instruction.
A - interpret line as address.
N - interpret line as signed octal number.

ignore any other keys struck.

SSW 3 - (sensed only when SSW 1 is up).

down: relativize addresses with respect to p (address of current location).

up: relativize addresses with respect to symbolic location 1A; octal number which is used as the value for 1A was read from the right switches after the termination of the display above.

Control will be returned to GUIDE at the completion of the disassembly printout.

Title COMPAR: Compare Contents of Tape Blocks (SRD)

Abstract This program will compare the contents of two tape blocks.

Usage After requesting the program in GUIDE, the following will be displayed on the scope:

```
COMPARE
BLOCK ??? ON UNIT ?
TO BLOCK ??? ON UNIT ?
FOR ??? BLOCKS
```

Answer the questions. Leading zeros are not necessary in any of the fields.

The program will begin comparing with the initial specified blocks, automatically increment each block number by one, and continue comparing until the number of blocks requested have been compared.

If the comparison is completed satisfactorily, the following will be displayed:

```
ALL AOK
```

Strike the EOL key and SSW0 becomes operative in the following manner:

SSW 0 - down: the program will return to GUIDE.

up: the program will return to the first display in COMPAR.

If the comparison is unsatisfactory, the following will be displayed:

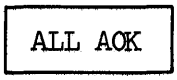
```
BAD COMPARE !

LOC      BLK      CONTENTS
nnnn     nnn        nnnn
         nnn        nnnn
```

"nnnn" under LOC will be the location relative to Q0 where the difference is found. The blocks and differing contents will be displayed under their proper headings. If tape unit 1 is referenced, a "u" will appear behind the appropriate block number. When the EOL key is struck, SSW1 becomes operative in the following manner:

SSW 1 - down: the rest of the block will be compared.

up: The rest of the block will not be compared. The program will either go to the next set of blocks to be compared or if no more blocks are to be compared,



will appear on the scope and SSW0 will become operative (see above).

Title INPRNT: Index Print (SRD)

Abstract By use of this program, a printed copy may be obtained on a Teletype machine connected to the LINC via bit 0 of the relay register, of any GUIDE index or LAP4 MS file. One line of LINC keyboard input is allowed before the index or file is printed.

Usage Initially, enough paper will be ejected from the Teletype so that any printing which remained in it may be torn off; likewise, ejection will occur at the end of each page.

The following information will be requested:

```
PRINT ?

0 MS FILE INDEX
1 GUIDE INDEX
```

Option 0 requests

```
FILE ?
UNIT ?
```

Option 1 requests

```
ON UNIT ?
```

If the MS file or GUIDE index is found, the program will expect keyboard input. Striking EOL terminates this and causes the printing of the MS file or index to commence.

After the printing is finished, SSW 0 becomes operative in the following manner:

SSW 0 - down: return to GUIDE
up: return to the first display above

If no MS file can be found, the following will be displayed on the scope:

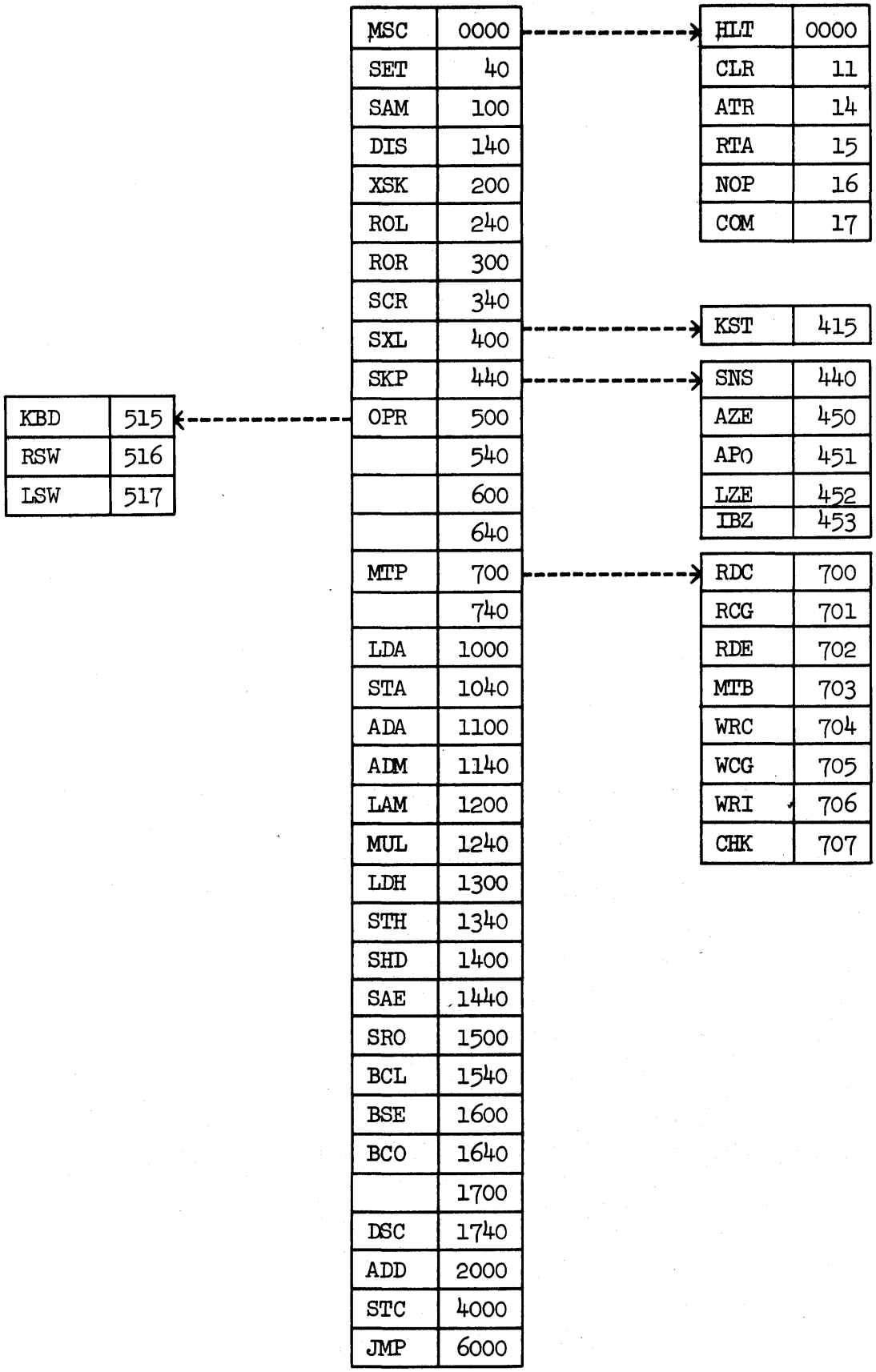
```
NO FILE HERE
```

If no GUIDE index can be found, the following will be displayed:

```
INDEX MISSING
```

In either case striking EOL will cause SSW 0 to become operative (see above).

ORDER CODE SUMMARY



MSC	0000
SET	40
SAM	100
DIS	140
XSK	200
ROL	240
ROR	300
SCR	340
SXL	400
SKP	440
OPR	500
	540
	600
	640
MTP	700
	740
LDA	1000
STA	1040
ADA	1100
ADM	1140
LAM	1200
MUL	1240
LDH	1300
STH	1340
SHD	1400
SAE	1440
SRO	1500
BCL	1540
BSE	1600
BCO	1640
	1700
DSC	1740
ADD	2000
STC	4000
JMP	6000

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

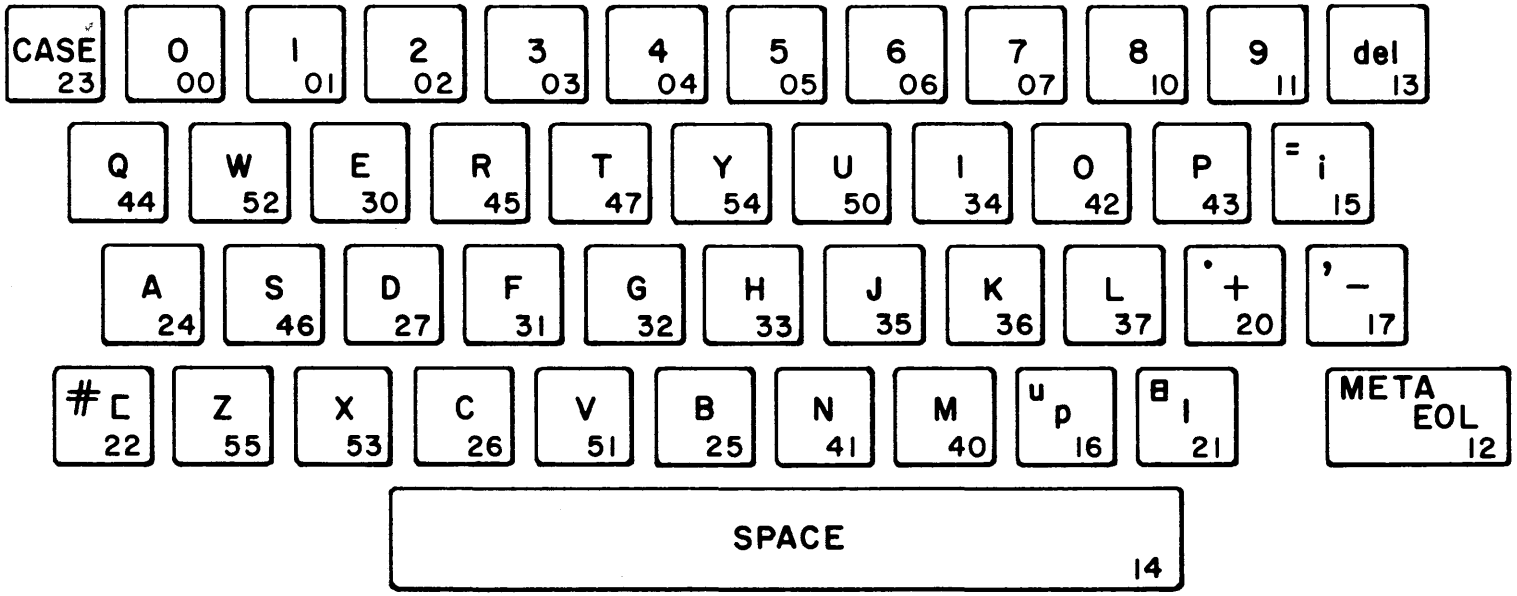
KST	415

SNS	440
AZE	450
APO	451
LZE	452
IBZ	453

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

KBD	515
RSW	516
LSW	517

KEYBOARD DIAGRAM WITH CODES



⊏	Comment	CASE	Case Shift
#	Tag	i	i-bit
⊟	Origin	=	Equality
u	Tape Unit	del	Delete
EOL	End of Line	|	QN BN
p	Present Location		

KEYBOARD CODES

Code	Character
00	0
01	1
02	2
03	3
04	4
05	5
06	6
07	7
10	8
11	9
12	EOL (META)
13	del
14	space
15	i (=)
16	p (u)
17	- (,)
20	+ (.)
21	| (⊟)
22	# ([)
23	CASE
24	A
25	B
26	C

Code	Character
27	D
30	E
31	F
32	G
33	H
34	I
35	J
36	K
37	L
40	M
41	N
42	O
43	P
44	Q
45	R
46	S
47	T
50	U
51	V
52	W
53	X
54	Y
55	Z

N.B. A character in parentheses is the upper case of the character which precedes it.

UTILITY SYSTEM TAPE ALLOCATION

Block	Allocation
000 - 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 (4000_8 lines) in unpacked form might exceed the working area assigned above, but the possibility is extremely remote.

LAP4 TAPE ALLOCATION

Block	Allocation
270 271 272 273 274 275 276 277	MANUSCRIPT CONTROL meta command
300	Regular input
301	COPY meta command
302	Temporary Storage
303 304 305 306	CV and CM meta commands
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
330 331 332 333	Binary program after conversion
334	Temporary storage
335	Manuscript control block
336 and ff.	Manuscript

GUIDE TAPE ALLOCATION

Block	Allocation
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 systems tape (CAST)
406	File a binary program (FILEBI)
407	Delete a filed program (DELETE)
410 - 477	Binary programs

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; insertions 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

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

SUMMARY OF ANSWERING PROCEDURE

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); proceed*	"	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*	"	"
complete entry in current question, no question marks remaining (EOL not yet struck)	"	proceed*	"	inoperative

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

PROGRAM MODIFICATIONS NECESSARY FOR

TELETYPE CONNECTION

Teletype attached to relay register		Program Changes					
Bit Number	Marks On	(Input) (Control)	MSPRNT 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 of the relay register bits 1 - 5 are used.

GLOSSARY

Address	a unique 11-bit binary number assigned to each 12-bit binary word (core storage location) in LINC memory; allowable range for addresses is $(0000 - 1777)_8$ for the 1024-word LINC and $(0000 - 3777)_8$ for the 2048-word LINC.
Assembler	a program which will translate program statements in a symbolic language closely resembling machine language into machine language.
β	refers to bits 0-3 of certain LINC 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 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 ([ ), used by the programmer to illuminate his MS, but ignored by LAP4 during conversion.
Compiler	a program which will translate 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 panel which contains the toggle switches, push-buttons, levers, rotary switches, and indicator lights; operation of this LINC 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 memory.
Delete	to remove a line of MS or an answer to a displayed question in this LINC utility system the key "del" is used.

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.
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 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 4 of certain LINC 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	the LINC Assembly Program 4; one of the two systems which comprise this LINC 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.
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 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.
Meta command	a line not retained by LAP4 as part of an MS; a direct, immediately-executed command to LAP4.
Mnemonics	3 character acronyms or abbreviations for the LINC instruction.
Object program	the binary generated by conversion of an MS.
Order code	the LINC instruction repertoire.
Origin	an MS line used to locate sections of a program in core storage at absolute addresses.
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.
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	1/4 of a standard (1024 word) LINC's memory; consists of 400_8 contiguous 12-bit words.
Regular input	the section of LAP4 which accepts input from the keyboard of MS lines and meta commands.
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 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.
Systems 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 tape unit 0 (left) or 1 (right).
Utility system	a programming system for the LINC composed of two communicating systems, LAP4 and GUIDE.
Working area	that section of a systems tape used by the LAP4 system for storing MS and the binary converted from MS; occupies blocks 330 and ff.