

## LINC ASSEMBLY PROGRAM 2

### LAP3

The following is a description of LAP3, a symbolic conversion program for the LINC which uses the LINC keyboard for on-line input, and the magnetic tapes for storage, working area, and output. The scopes are used to provide readable manuscript.

#### I. General Information

##### A. Operating Procedure

1. LAP3 occupies Blocks 300 - 327 of the tape, plus Blocks 330 and following for "working area" (see Chart IV). The tape must be on Unit 0.
2. To operate, READ BLOCK 300 into QUARTER 0, and START at 0. A "I" will appear on the scopes to indicate the LAP3 is ready to accept keyboard input. This is the only start or restart procedure.
3. Lines of manuscript and meta are typed into the computer via the keyboard. LAP3 displays on both scopes 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 100 - 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  $17_{10}$  struck characters. This includes spaces, case shifts, and the terminator.

3. Manuscript lines are always terminated by striking the "End-of-Line" key, EOL. Lines which are too long are automatically terminated with an EOL by LAP3 and called to the attention of the typist. (See Error Detection)

#### C. Manuscript Line Numbers

1. LAP3 assigns a "line number" to every line entered. The numbering appears at the upper left of the line on the scopes; 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 scopes.

Example: The following sequence will appear on the scopes one line at a time as it is typed:

```
1 ADD 3          ---hit EOL---
2 STC 5          ---hit EOL---
3 JMP 56         ---hit EOL---
4 STA           ---hit "del;" line 4 is deleted---
3 JMP 56         ---line 3 reappears; type line 4 again---
4 STC 10        ---hit EOL---
5              ---next line number appears; hit "del"---
3 JMP 56         ---line 4 is deleted, line 3 reappears; hit "del"-
2 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 scopes 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 Chart II) are displayed except EOL, del, and CASE.

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 Chart II), and LAP3 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. LAP3 returns to lower case automatically.

## 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.

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

1                    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. If it appears after, the origin will be interpreted incorrectly.
4. Origins may be specified throughout the program. If portions of the binary overlap as a result, the later origins take precedence.
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 (L). 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.
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; ~~\*/~~ 2 A 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.

#### D. Symbolic Operation Mnemonics

1. All first-order three letter mnemonics for operation codes are permitted except MSC. Substitute mnemonics as defined by Chart 1 are also permitted.

2. The mnemonics used must agree with Chart 1, except that the second character may be replaced by any other capital letter.

e.g. JMP or JBP are both acceptable for JUMP.

JIP is not.

3. No spaces are permitted within the mnemonic.

#### E. Special Symbols

1. Bit 4 (the i-bit) is specified symbolically with "i."

2. Bit 3 (the tape unit bit) is specified symbolically with "u".

3. The vertical bar ( | ) is used in the second register 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 in assigning the sign of a number. The "-" symbol is also interpreted as "dash" for some of the meta commands.

e.g. -567 will be converted to 7210.

6. The equality symbol, =, is used to assign a value to an undefined tag in an address field. 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 "letter, number" combination must be on the left of the "=" symbol; the numerical assignment on the right.
- c. No spaces are permitted anywhere on an equality line.
- d. The numerical assignment may not be signed.

e.g. 6G=7774 is legal;

6G=3 is not.

#### F. Numerals

1. Numerals on any line of manuscript or in any meta command must be octal constants. LAP3 will convert to zero 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 tags, 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 tags in the address field are assigned the value zero.

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

4. For multiply defined tags, LAP3 will use the last one entered in the manuscript for the assignment, regardless of whether it was entered with // or =.

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

<u>Location</u>		<u>Conversion</u>
	☐ 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 (X) or a comment (E) 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 compiler 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 and the keyboard is briefly locked. When the keyboard releases, the typist must hit either: "del," which will delete the line, or "G," (for GO) which will accept the line as usual. The keyboard will repeatedly lock until one of these keys has been struck.
3. Error detection for faulty meta commands is somewhat different, and will be described below.

## J. Line Format

### 1. Program Lines

- a. The following formats for program lines are permissible (spaces optional):

```

// 3K SAE i 5
# 3K i SAE 5
// 3K SAE 5 i
// 3K 5 i SAE
# 7S RDC u i

```

- b. The formats

```

// 3K 5 SAE i
// 3K i5 SAE
// 3K 3X+5 STC

```

are permitted, but the space is required between the "5" and the "S."

- c. "i" and "u" may come anywhere on a line.
- d. Generally, any format is acceptable, so long as
  - 1) Tags come first.

- 2) Numbers and letters are distinguished from "number, letter" tag combinations. (Examples in b. above.)

### III. Meta Commands

A. LAP3 provides nine 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, LAP3 returns to normal input operation, displaying the current line number on the scopes. Continue typing.

B. Errors: there are two kinds

1. When a faulty meta command is entered with the META key, a question mark (?) will appear on the scopes following the command, and the keyboard will lock briefly. The only key LAP3 will accept at this point is "del." Try again.
2. Once the command has been accepted, if LAP3 finds that it cannot then be executed, a "NO" will appear on the scopes. (This does not happen until the tapes have churned a while and LAP3 has at least tried.) The "NO" will remain on the scopes until a key (any key) is struck; LAP3 will return to normal input operation displaying the current line number. The manuscript entered up to this point is still intact (except with READ MANUSCRIPT).

C. Formats

1. Meta commands must be at least two letters as specified on Chart III. If no numeric parameters follow, any other characters may also be typed: e.g., "Display" may be specified with DI, DIS, DISP, DISPLAY, etc., so long as the "DI" is present. However, when numeric parameters follow, only two letters are permitted.

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

D. Except for "Read Manuscript," "Copy," and "Convert Manuscripts," commands are effective only for manuscript in the working area of the tape.

E. Commands

1. REMOVE

Format: RE LN,n<sub>META</sub>

or: RE LN-LN+n<sub>META</sub>

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 remove, or by a "-" and the first line number after the area to be removed.

Example: To remove 5 lines beginning with line 230, when the manuscript presently goes through line 402, type

403 RE 230,5<sub>META</sub> or 403 RE 230-235<sub>META</sub>

When the META character is entered, LAP3 will execute to command; the rest of the manuscript is automatically renumbered, and LAP3 returns to normal input operation by displaying a 376 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.

Example: To remove the last 10 lines of a manuscript which presently ends at line 164, type





hold the display stationary. Hitting the CASE key when this knob is on stationary will advance the display by one frame (e.g. for taking pictures).

- b. Lines are displayed with line numbers.
- c. To terminate the display, hit EOL. LAP3 will return to normal input operations.
- d. If a request is given to DISPLAY an unpacked manuscript, LAP3 will PACK it automatically before displaying it.

5. SAVE MANUSCRIPT            Format: SM<sub>META</sub>

- a. Manuscript in the working area of the LAP3 tape can be saved at any time in any consecutive blocks on either unit. Saving manuscript more frequently than you think necessary is recommended. Saving manuscript in the LAP3 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<sub>META</sub>", the following appears on the scopes:

```
SAVE
n BLOCKS
AT BLOCK ?,
UNIT ?
```

- 1) "n," supplied by LAP3, 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 second EOL.) If LAP3 doesn't like what you typed, the question mark(s) will reappear automatically when the EOLs are struck.

d. After the SAVE, LAP3 will return to normal input operation; the manuscript will be as it was before the command was executed.

6. READ MANUSCRIPT                      Format: RM BN,UN<sub>META</sub>

READ MANUSCRIPT will restore a manuscript which has been SAVED to the working area of the LAP3 tape. Type "RM" followed by the block number (BM), a comma, and the unit number (UN) specifying the present location of the manuscript.

a. Only manuscripts which have been saved with a SAVE MANUSCRIPT can be read with a READ MANUSCRIPT.

b. When the command is executed, LAP3 will return with the present line number for the manuscript just read. Continue typing.

c. LAP3 will return with a "NO" when either the BN or the UN requested is illegal, or when there is no SAVED manuscript at that location. Hitting a key (any key) at this point will return LAP3 to normal input operation, but it will return with a "1" as the present line number. Whatever you were typing up to the READ command is effectively lost.

7. CONVERT                                      Format: CV<sub>META</sub>

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 LAP3 tape) after conversion. Block numbers correspond to memory quarters 0 - 3 respectively.

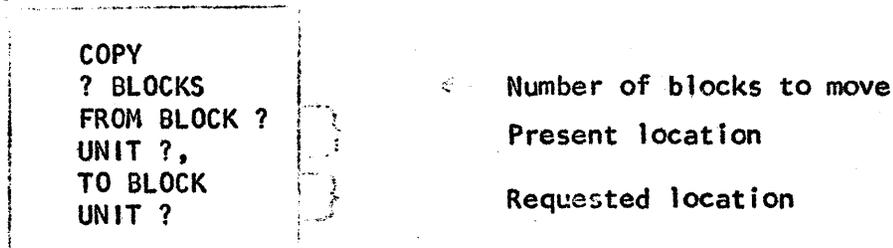


g. As with CV, the binary conversion will be in blocks 330 - 333 on unit 0, block numbers corresponding to memory quarters 0 - 3, respectively.

h. A 'NO' will appear if LAP3 finds that any of the blocks specified does not contain the beginning of a SAVED manuscript.

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 scopes:



a. Fill in the question marks as indicated, terminating each line entry with EOL. The command will be executed when the last EOL is typed after line 6 above. Hitting 'del' will delete entries, one at a time. LAP3 will delete illegal entries automatically.

b. Since LAP3 can only copy 3 blocks at a time (because of memory limitations), care should be taken not to overlap the block numbers when requesting a COPY. Example:  
Requesting a COPY of 6 blocks from block 550 to block 553 on the same unit will not work. Requesting a COPY of 3 blocks, however, from block 550 to block 551 on the same unit will work. (Obviously, if the units are different the COPY will be successful.)

c. After the COPY, LAP3 will return to normal input operation; the manuscript in the working area will be as it was before the command.

NOTE: Chart 1 is Order Code

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Chart III. LAP3 Meta Commands

Command	Required Format	May be followed by other characters
1. Remove	RE LN,n RE, LN=N	No
2. Insert End Meta	IN LN EN	
3. Pack	PA	Yes
4. Display	DI	
5. Save Manuscript	SM	
6. Read Manuscript	RM BN,UN	No
7. Convert	CV	Yes
8. Convert Manuscripts	CM	
9. Copy	CP	

Chart IV. LAP3 Tape Allocation

Block	Allocation
300-322	LAP3
323	Temporary Storage
324-325	Inserts
326-327	LAP3
330-333	Binary
334	Temporary Storage
335	Manuscript Control Block
336 and ff.	Manuscript

CHART 11

CASE 23	0 00	1 01	2 02	3 03	4 04	5 05	6 06	7 07	8 10	9 11	del 13
Q 44	W 52	E 30	R 45	T 47	Y 54	U 50	I 34	O 42	P 43	= i 15	
A 24	S 46	D 27	F 31	G 32	H 33	J 35	K 36	L 37	· + 20	' - 17	
* 22	Z 55	X 53	C 26	V 51	B 25	N 41	M 40	u P 16	⌊ 1 21	META EOL 12	
SPACE											14

⌊	Comment	CASE	Case Shift
#	Tag	i	i-bit
⌊	Origin	=	Equality
u	Tape Unit	del	Delete
EOL	End of Line		QN BN

LINC III KEYBOARD CODING

ENG: M.A.W.  
DATE: 5-9-63