Version 1, September 2009. **CCS-L1X3**

LEO I instruction set.

Program actions on the *LEO I* computer

Each instruction of a LEO I program consisted of three parts. They were: the action to be carried out, the address of the compartment affected and the discriminant denoting the length of the compartment. Initially, following EDSAC practice, these parts were written as: Action Letter, Address Number and Suffix Letter (discriminant). Thus an instruction to add the contents of compartment 106 into the accumulator was perforated onto paper tape as:

A 106 F for a short number
A 106 D for a long number

ON LEO I this was later changed and a purely numerical notation was used and perforated onto paper tape as:

28 106 17 for a short number
28 106 19 for a long number

The format of the instruction was:

5	1	10	1
Action	Sp	Address	suffix

Of the 32 possible actions (0 to 31) only 17 were provided when LEO I was first used. These 17 are identified in the full list below by the insertion, in brackets, of the original EDSAC action letter beside the corresponding action number. Eventually, as development proceeded, 30 actions were available to programmers. Some of the actions became redundant, but new actions were added. In the end values 0, 9 and 15 were not used, but 29 performed two different functions according to the value of the discriminant. The actions fell into three broad categories.

Sequence control actions: 2, 3, 13, 27 and 29.
Arithmetic and data manipulation actions: 1, 4, 5, 6, 7, 8, 12, 14, 21, 22, 25, 26, 28, 30 and 31.
Input and output actions: 10, 11, 16, 17, 18, 19, 20, 23, and 24.

The data for this, and the list which follows, has been gathered from two sources:

1. The EDSAC Simulator available from http://www.dcs.warwick.ac.uk/~edsac/

2. Peter J. Bird's book "LEO: The First Business Computer", see http://www.leocomputers.org.uk/newbooks.htm I had the pleasure of contributing the list of LEO installations and some paragraphs, supplying some photographs, proof checking the book and suggesting the title.

Instruction set for LEO I.

Action number/name	***description***
1 CLEAR	Clear double compartment specified and all later compartments in same tube of store.
2 CONDITIONAL STOP	If external switch has been set, reset calculator ready to carry out next order when restart button is pressed and light stop lamp, otherwise proceed to next order.
3 (E) TEST POSITIVE	Test sign position of accumulator. If it contains ‘0’, change sequence to order contained in compartment specified by address.
4 (R) SHIFT RIGHT	Shift right contents of accumulator by number of positions indicated by position of first ‘1’ in address.
5 (T) TRANSFER FROM ACCUMULATOR	Transfer the most significant 17 or 35 digits of contents of accumulator into compartment specified by address and clear accumulator.
6 (Y) ROUND OFF	Round off contents of accumulator to 34 significant places by adding a ‘1’ into the more significant of the second half of accumulator.
7 (U) COPY FROM ACCUMULATOR	Copy contents of accumulator into compartment specified by address.
8 NEGATIVE AGGREGATE *	Clear accumulator and subtract from it contents of double compartment specified and all later double compartments in same tube of store.
10 CARD PUNCH OUTPUT	Send out results for punching on a card from first twelve double compartments of tube specified.
11 TABULATOR OUTPUT	Send out results for printing by tabulator from tube specified.
12 (S) SUBTRACT	Subtract from accumulator contents of

	compartment specified.
13 (Z) STOP	Reset calculator ready to carry out next order when restart button is pressed and light stop lamp.
14 SELECT	Replace contents of accumulator by contents of compartment specified by address.
16 CONVERT HOLLERITH	Convert a number held in Hollerith notation in tube specified to binary.
17 (F) CONVERT DECIMAL **	Select long number from address specified and convert from binary-decimal to full binary and add result into more significant half of accumulator.
18 CONVERT STERLING	Select long number from address specified and convert from binary-sterling into full binary and add result into more significant half of accumulator.
19 RECONVERT DECIMAL OR STERLING	Reconvert long number in full binary into punched notation in special output tube. According to what is specified in order, express in decimal or sterling. Use number of digit positions specified and start a new line of results.
20 TAPE INPUT 1	Clear tube of store specified and put into it next block of information from No. 1 paper tape.
21 (H) SET UP IN MULTIPLIER	Set up in multiplier register contents of compartment specified by address.
22 (N) MULTIPLY NEGATIVELY	Multiply contents of compartment specified by contents of multiplier register and subtract result from accumulator.
23 TAPE OR CARD INPUT 2	Clear tube of store specified and put into it next block of information from No. 2 paper tape or put into first twelve double compartments of it next block of information from No 2 card feed.

24 CARD INPUT 1	Clear tube of store specified and put into first twelve double compartments of it next block of information from No 1 card feed.
25 (L) SHIFT LEFT	Shift left contents of accumulator by number of positions indicated by first ‘1’ in order.
26 (X) AUGMENT	Augment contents of accumulator to the contents of compartment specified by address and clear accumulator.
27 (G) TEST NEGATIVE	Test sign position of accumulator. If it contains ‘1’, change sequence to order contained in compartment specified by address.
28 (A) ADD	Add into accumulator contents of compartment specified by address.
29 TEST with short discriminant	Test the contents of accumulator. If there is a ‘1’ in any position, change sequence to NON-ZERO order contained in compartment specified by address.
29 TEST with long discriminant	Test the contents of accumulator. If there is a not ‘1’ in any position, change sequence to order contained in compartment specified by address.
30 (C) COLLATE	Compare contents of compartment and multiplier register and add ‘1’ into accumulator where there is a ‘1’ in both numbers.
31 (V) MULTIPLY	Multiply contents of compartment specified by address by contents of multiplier register and add result to contents of accumulator.

* *On EDSAC action (I) was input next character from paper tape.*

** *On EDSAC action (F) was read last character output for verification.*

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