# 60173 Program Description I

Program Title 97-Game of Life (23 x 31)

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Program Description, Equations, Variables A number of counters (organisms) are placed on an infinite checkerboard to form an arbitrary initial pattern. At every move (generation) a counter is either left on its square (it survives) or removed from the board (it dies). On certain free squares new counters are placed (births). This simulated evolution is governed by simple rules. - Each square on the board has eight neighbouring squares, four adjacent orthogonally, four adjacent diagonally. The rules are: 1. Survivals. Every counter with two or three neighbouring counters survives for the next generation. 2. Deaths. Each counter with four or more neighbours dies from overpopulation. Every counter with one neighbour or none dies from isolation. 3. Births. Each empty square adjacent to exactly three neighbours is a birth cell. A counter is placed on it at the next move. - All births and deaths occur simultaneously, together they constitute a single generation. - For an example see fig. A on page 3. It is the simplest oscillating pattern and has a period of two.

The programme is recorded on two magnetic cards, the main part is on card 1 while card 2 is used for the input/output procedure, which essentially converts binary into decimal numbers and vica-versa.

Operating Limits and Warnings The board pattern is stored in the form of binary numbers - one number per row. This explains the possible large size of the board (25 squares vertically, 33 horizontally). However, to decrease calculation times the calculated part of the board is always restricted to the smallest possible size. Part of this procedure is the location of the pattern as close to the bottom right-hand corner of the board as possible. This occurs after every generation.

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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**Program Description, Equations, Variables** (cont.) Any such shift is documented on the print-out (otherwise the absolute position of the resulting pattern would be unknown). The best way to deal with these shifts is as follows. Draw every generation at the bottom right-hand corner of an imaginary infinite checkerboard (represented by two orthogonal lines on square paper). Mark the corner of the first generation. This is your "frame of rest". Shift this mark instead of the whole pattern from one generation to the next whenever a shift print-out (recognizable by DSP 1) occurs between two generations. These print-outs and the corresponding shifts are:

0.5 *** → Shift one square to the left.

2.0 *** → Shift one square to the right.

1.0 *** → Shift one square up.

0.0 *** → Shift one square down.

For an example see sample problem (1).

**Operating Limits and Warnings** Although the maximum size of the board is 25 x 33 an error display occurs and no further generations are calculated when the pattern exceeds 23 x 31. This is because counters on a square at the edge of the board*) could cause "hidden births" at the next move. - *) This does not affect the input/output format in which the pattern is always shifted as far as possible to the bottom right-hand corner of the board.

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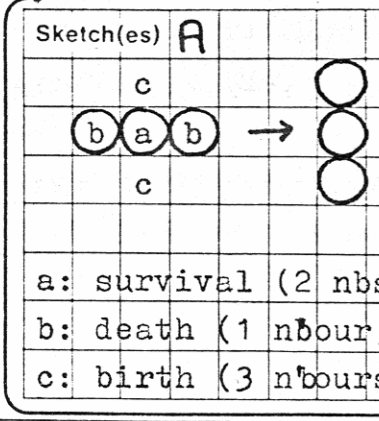
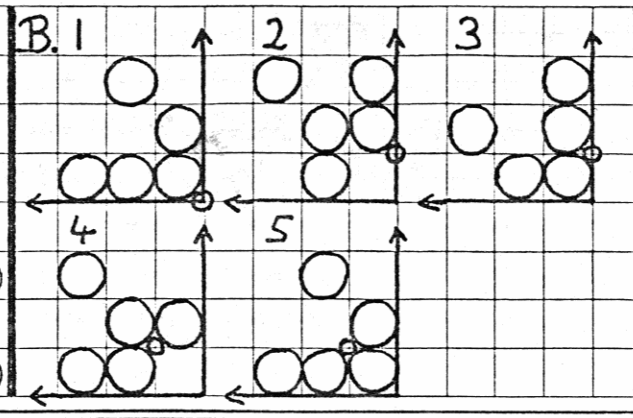
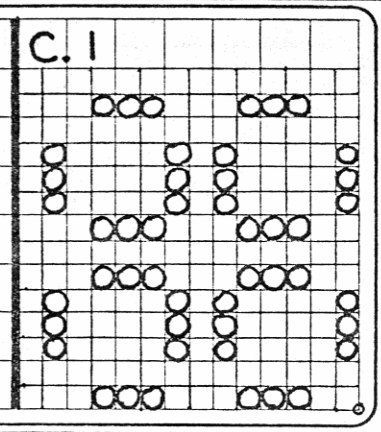
Sketch(es) A




a: survival (2 nbs.)
b: death (1 nbour)
c: birth (3 nbours)




**Sample Problem(s)** (1) Calculate the evolution of the pattern in fig. B.1 without using data cards.

(2) Calculate the evolution of the pattern in fig. C.1 with the aidn of data cards.

SOLUTIONS: (1) Load card 2

Keystrokes: [A] [C] [B] [D] [C] [D] [C] [C] [C] [E] → 0.000000010 ***
Load card 1 — 0.000000001 *** } Fig. B.1
Press key [A] — 0.000000111 ***

→ 2. *** / 1. *** / 7. *** } Fig. B.1 — 'Crd'

[R/S] → 1.0 *** (upshift)

5. *** / 3. *** / 2. *** } Fig. B.2 — 'Crd'

[R/S] → 1. *** / 5. *** / 3. *** } Fig. B.3 — 'Crd'

[R/S] → 0.5 *** (left-shift)

4. *** / 3. *** / 6. *** } Fig. B.4 — 'Crd'

[R/S] → 2. *** / 1. *** / 7. *** } Fig. B.5 — 'Crd'

~~Solutions~~ Press key [R/S] twice to stop programme.

Because the fifth print-out equals the first which represents the initial position (fig. B.1) only the three middle print-outs are used in the output procedure: Load card 2

Keystrokes: [A] 5 [f] [C] [D] 3 [f] [C] [D] 2 [f] [C] [E] → 0.000000101 *** (Fig. B.2)
[A] 1 [f] [C] [D] 5 [f] [C] [D] 3 [f] [C] [E] → 0.000000001 *** / 0.000000011 ***
[A] 4 [f] [C] [D] 3 [f] [C] [D] — 0.000000101 *** / 0.000000010 ***
6 [f] [C] [E] — 0.000000011 *** (Fig. B.3)
→ 0.000000100 *** / 0.000000011 *** / 0.000000110 *** (Fig. B.4)

~~References~~ The three sets of binary numbers resulting apparently correspond to patterns B.2, B.3 and B.4 respectively. Shift your mark (see programme description) as follows: Upshift between patterns 1 and 2 (1.0 ***), left-shift between patterns 3 and 4 (0.5 ***). If you compare the marks in patterns 1 and 5 it follows that the

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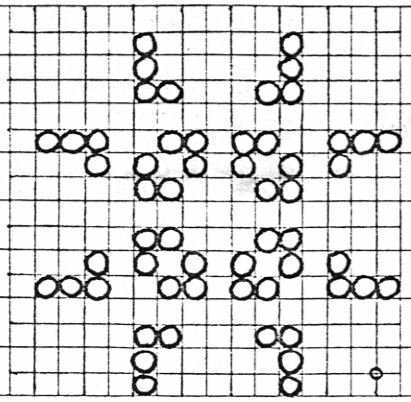
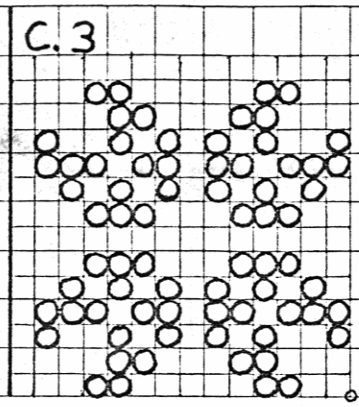
Sketch(es)

C.2



C.3



It follows that the pattern C is oszillating with a period of three.

~~Examples Problem(s)~~ SOLUTIONS (cont.): pattern has moved one square to the right and downwards diagonally within four generations.

(2) Load card 2

Keystrokes: [A] [C] [C] [C] [B] [B] [B] [C] [C] [C] [B] [B] [D] [D] [C] [B] [B] [B] [B] [C] [B] [C] [B] [B] [B] [B] [C] [D] [f] [E] [D] [f] [E] [D] [C] [C] [C] [B] [B] [B] [C] [C] [C] [B] [B] [D] [D] [C] [C] [C] [B] [B] [B] [C] [C] [C] [B] [B] [D] [C] [B] [B] [B] [B] [C] [B] [C] [B] [B] [B] [B] [C] [D] [f] [E] [D] [f] [E] [D] [D] [C] [C] [C] [B] [B] [B] [C] [C] [C] [B] [B] [E] → 0.000000001 ***

1.100011100 ***

0.000000000 ***

0.000000100 ***

0.010100001 *** etc.

You have to read those numbers which are not separated by one space as one line of the board pattern, disregarding the points. Thus these first three lines of the control print-out represent the first three lines in fig.C.1.

Solution(s) Load card 1

Press key [A] → 1st generation print-out → 'Crd'

Press key [R/S] → 1.0 *** (upshift), 0.5 *** (left-shift),
2nd generation print-out → 'Crd'

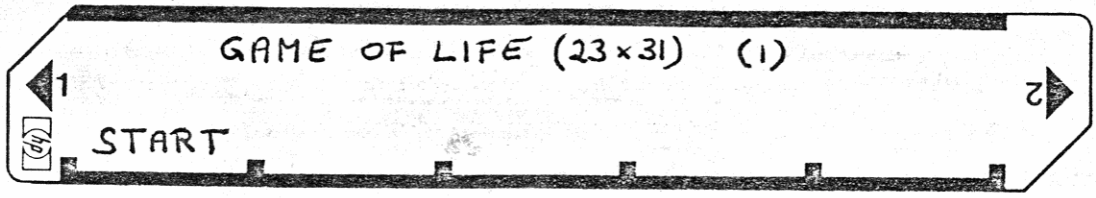
Record data → 0.0 *** (downshift), 2.0 *** (right-shift),
3rd generation print-out → 'Crd'

Record data → 4th print-out (equals 1st) → 'Crd'; Stop programme;
Load card 2; Load data card 1; Press keys [f] [A] → Output pattern C.2.

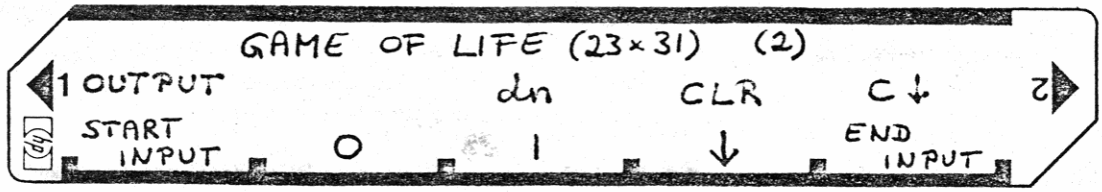
Load data card 2; Press keys [f] [A] → Output pattern C.3 (see above).

Reference(s) Martin Gardner, Scientific American, Oct. 1970, pp 120-123.

GAME OF LIFE (23×31) (1)




| STEP | INSTRUCTIONS | INPUT DATA/UNITS | KEYS | | OUTPUT DATA/UNITS |
|---|---|---|---|---|---|
| 1 | Load side 1 and side 2 of card 2 | | | | |
| 2 | Start input | | | A | |
| 3 | Consider the top line of the pattern | | | | |
| | from left to right | | | | |
| 4 | a) Input empty square* | | | B | |
| | b) Input covered square | | | C | |
| | c) If you make a mistake: Clear line | | f | D | |
| 5 | Repeat step 4 until you have finished | | | | |
| | the line | | | | |
| 6 | Is there another line ? | | | | |
| | Yes: Go to step 7 / No: Go to step 12 | | | | |
| 7 | Next line | | | D | |
| 8 | Consider the next line | | | | |
| 9 | Is it equal to the previous one ? | | | | |
| | Yes: Go to step 10 / No: Go to step 4 | | | | |
| 10 | Copy line | | f | E | |
| 11 | Go to step 6 | | | | |
| 12 | End input | | | E | Control |
| | | | | | -output |
| 13 | Load side 1 and side 2 of card 1 | | | | |
| 14 | Do you wish to calculate many genera- | | | | |
| | tions without interruption ? | | | | |
| | Yes: Go to step 15/ No: Go to step 19 | | | | |
| 15 | Delete programme step 030 (WDTA) | | | | |
| 16 | Start | | | A | |
| | Successive generations are being | | | | Generation |
| | evaluated now** | | | | -outputs |
| 17 | To stop calculations: Stop programme | | | R/S | |
| 18 | Go to step 24 | | | | |
| 19 | Start | | | A | 1st Gen- |
| | | | | | output |
| | | | | | 'Crd' |
| 20 | Clear 'Crd' | | | R/S | |
| | (See next page) | | | | |
| * | Can be omitted left of the first | | | | |
| | covered square in a row | | | | |
| ** | The time varies, depending on the | | | | |
| | size of the pattern, between a few | | | | |
| | minutes and one or two hours | | | | |




| STEP | INSTRUCTIONS | INPUT DATA/UNITS | KEYS | | OUTPUT DATA/UNITS |
|---|---|---|---|---|---|
| 20a | The next generation is now being | | | | Next Gen. |
| | evaluated**;(To stop calculations | | | | -output |
| | go to step 17) | | | | 'Crd' |
| 21 | Do you want to store the generation | | | | |
| | on a data card*** ? | | | | |
| | Yes: Go to step 22/ No: Go to step 20 | | | | |
| 22 | Record data on one side of a data card | | | | |
| | If 'Crd' is displayed: Record on the | | | | |
| | other side, too | | | | |
| 23 | Go to step 20a | | | | |
| 24 | Load side 1 and side 2 of card 2 | | | | |
| 25 | Data cards available ? | | | | |
| | Yes: Go to step 26/ No: Go to step 29 | | | | |
| 26 | Load data card | | | | |
| 27 | Output | | f | A | Pattern |
| 28 | Go to step 35 | | | | -output |
| 29 | Start input | | | A | |
| 30 | Input decimal number | dn | f | C | |
| 31 | Is there another number (line) in the | | | | |
| | same generation print-out ? | | | | |
| | Yes: Go to step 32/ No: Go to step 34 | | | | |
| 32 | Next line | | | D | |
| 33 | Go to step 30 | | | | |
| 34 | End input | | | E | Pattern |
| 35 | For another generation go to step 25 | | | | -output |
| 36 | For a new problem go to step 2 | | | | |
| | | | | | |
| | | | | | |
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| | | | | | |
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| | | | | | |
| | | | | | |
| | | | | | |
| *** | This merely saves you keying in the | | | | |
| | print-out in the output-procedure | | | | |

| STEP | KEY ENTRY | KEY CODE | COMMENTS |
|---|---|---|---|
| 001 | *LBLA | 21 11 | Start |
| 002 | SF0 | 16 21 00 | |
| 003 | CF1 | 16 22 01 | |
| 004 | CF3 | 16 22 03 | |
| 005 | GSBd | 23 16 14 | |
| 006 | ISZI | 16 26 46 | |
| 007 | *LBL3 | 21 03 | register≠ 0 with maxim. index ? |
| 008 | DSZI | 16 25 46 | |
| 009 | DSP0 | -63 00 | |
| 010 | RCLi | 36 45 | |
| 011 | X=0? | 16-43 | |
| 012 | GTO3 | 22 03 | |
| 013 | RCLI | 36 46 | |
| 014 | 3 | 03 | |
| 015 | 2 | 02 | |
| 016 | ISZI | 16 26 46 | |
| 017 | 0 | 00 | |
| 018 | SPC | 16-11 | |
| 019 | *LBL4 | 21 04 | |
| 020 | DSZI | 16 25 46 | |
| 021 | SF2 | 16 21 02 | |
| 022 | RCLi | 36 45 | |
| 023 | PRTX | -14 | print line |
| 024 | X>Y? | 16-34 | max? |
| 025 | X≷Y | -41 | |
| 026 | R↓ | -31 | |
| 027 | F2? | 16 23 02 | |
| 028 | GTO4 | 22 04 | |
| 029 | SPC | 16-11 | |
| 030 | WDTA | 16-61 | data card boundaries |
| 031 | LN | 32 | |
| 032 | 2 | 02 | |
| 033 | LN | 32 | |
| 034 | ÷ | -24 | |
| 035 | INT | 16 34 | |
| 036 | 2 | 02 | |
| 037 | + | -55 | |
| 038 | X>Y? | 16-34 | ⟷ ? |
| 039 | GTOE | 22 15 | 'Error' |
| 040 | 2 | 02 | |
| 041 | 5 | 05 | |
| 042 | R↑ | 16-31 | |
| 043 | 3 | 03 | |
| 044 | + | -55 | |
| 045 | X>Y? | 16-34 | ↕ ? |
| 046 | GTOE | 22 15 | 'Error' |
| 047 | X≠I | 16-41 | |
| 048 | R↑ | 16-31 | |
| 049 | X≷Y | -41 | |
| 050 | R↑ | 16-31 | |
| 051 | *LBL2 | 21 02 | main loop |
| 052 | 1 | 01 | |
| 053 | + | -55 | |
| 054 | 1/X | 52 | |
| 055 | CHS | -22 | |
| 056 | RCLI | 36 46 | |
| 057 | + | -55 | |
| 058 | DSP4 | -63 04 | |
| 059 | RND | 16 24 | |
| 060 | STOI | 35 46 | |
| 061 | DSP2 | -63 02 | |
| 062 | RND | 16 24 | |
| 063 | X<0? | 16-45 | last square ? |
| 064 | GTO5 | 22 05 | |
| 065 | FRC | 16 44 | |
| 066 | X≠0? | 16-42 | |
| 067 | GTO0 | 22 00 | |
| 068 | CLX | -51 | |
| 069 | LSTX | 16-63 | |
| 070 | STOI | 35 46 | |
| 071 | *LBL0 | 21 00 | |
| 072 | DSP0 | -63 00 | |
| 073 | R↓ | -31 | |
| 074 | GSBa | 23 16 11 | |
| 075 | F1? | 16 23 01 | |
| 076 | GTO1 | 22 01 | |
| 077 | DSZI | 16 25 46 | |
| 078 | SF0 | 16 21 00 | |
| 079 | RCLI | 36 46 | |
| 080 | X=0? | 16-43 | |
| 081 | SF1 | 16 21 01 | |
| 082 | GSBe | 23 16 15 | |
| 083 | X≠0? | 16-42 | |
| 084 | SF3 | 16 21 03 | |
| 085 | DSZI | 16 25 46 | |
| 086 | *LBL2 | 21 02 | blind label |
| 087 | F0? | 16 23 00 | |
| 088 | GSBe | 23 16 15 | |
| 089 | ISZI | 16 26 46 | |
| 090 | CF0 | 16 22 00 | |
| 091 | ISZI | 16 26 46 | |
| 092 | R↓ | -31 | |
| 093 | *LBL1 | 21 01 | |
| 094 | ENT↑ | -21 | |
| 095 | ENT↑ | -21 | |
| 096 | 1 | 01 | |
| 097 | 1 | 01 | |
| 098 | . | -62 | |
| 099 | 1 | 01 | |
| 100 | x | -35 | |
| 101 | FRC | 16 44 | |
| 102 | 1 | 01 | |
| 103 | 0 | 00 | |
| 104 | x | -35 | number of neighbours |
| 105 | INT | 16 34 | |
| 106 | 4 | 04 | |
| 107 | - | -45 | |
| 108 | X≠0? | 16-42 | |
| 109 | GTO0 | 22 00 | |
| 110 | F2? | 16 23 02 | |
| 111 | GSBb | 23 16 12 | |
| 112 | *LBL0 | 21 00 | |

REGISTERS

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0 used | 1 used | 2 used | 3 used | 4 used | 5 used | 6 used | 7 used | 8 used | 9 used |
| S0 used | S1 used | S2 used | S3 used | S4 used | S5 used | S6 used | S7 used | S8 used | S9 used |
| A used | B used | C used | D used | E used | I used | | | | |

| STEP | KEY ENTRY | KEY CODE | COMMENTS |
|---|---|---|---|
| 113 | CF2 | 16 22 02 | |
| 114 | 1 | 01 | |
| 115 | + | -55 | |
| 116 | X=0? | 16-43 | |
| 117 | GSBb | 23 16 12 | |
| 118 | F3? | 16 23 03 | |
| 119 | SF2 | 16 21 02 | |
| 120 | CLX | -51 | |
| 121 | 1 | 01 | |
| 122 | 0 | 00 | |
| 123 | ÷ | -24 | |
| 124 | DSP2 | -63 02 | |
| 125 | RND | 16 24 | |
| 126 | R↑ | 16-31 | |
| 127 | GTO2 | 22 02 | |
| 128 | *LBL5 | 21 05 | Shift routine |
| 129 | DSP1 | -63 01 | |
| 130 | RCL0 | 36 00 | |
| 131 | X≠0? | 16-42 | |
| 132 | GTO1 | 22 01 | |
| 133 | GSBc | 23 16 13 | |
| 134 | F3? | 16 23 03 | |
| 135 | GTO6 | 22 06 | |
| 136 | R/S | 51 | |
| 137 | *LBL6 | 21 06 | |
| 138 | RCL0 | 36 00 | |
| 139 | X≠0? | 16-42 | |
| 140 | GTO0 | 22 00 | |
| 141 | PRTX | -14 | |
| 142 | GSBc | 23 16 13 | |
| 143 | GTO6 | 22 06 | |
| 144 | *LBL1 | 21 01 | |
| 145 | 1 | 01 | |
| 146 | FIX | -11 | |
| 147 | PRTX | -14 | |
| 148 | *LBL0 | 21 00 | |
| 149 | SF3 | 16 21 03 | |
| 150 | *LBL7 | 21 07 | |
| 151 | GSBd | 23 16 14 | |
| 152 | ISZI | 16 26 46 | |
| 153 | *LBL8 | 21 08 | |
| 154 | DSZI | 16 25 46 | |
| 155 | SF2 | 16 21 02 | |
| 156 | RCLi | 36 45 | |
| 157 | 2 | 02 | |
| 158 | ÷ | -24 | |
| 159 | FRC | 16 44 | |
| 160 | X=0? | 16-43 | |
| 161 | GTO0 | 22 00 | |
| 162 | F3? | 16 23 03 | |
| 163 | PRTX | -14 | |
| 164 | GTOA | 22 11 | |
| 165 | *LBL0 | 21 00 | |
| 166 | F2? | 16 23 02 | |
| 167 | GTO8 | 22 08 | |
| 168 | GSBd | 23 16 14 | |

number of neighbours

blind (prt***)

| STEP | KEY ENTRY | KEY CODE | COMMENTS |
|---|---|---|---|
| 169 | 2 | 02 | |
| 170 | *LBL9 | 21 09 | |
| 171 | ST÷i | 35-24 45 | |
| 172 | DSZI | 16 25 46 | |
| 173 | GTO9 | 22 09 | |
| 174 | ST÷0 | 35-24 00 | |
| 175 | F3? | 16 23 03 | |
| 176 | F3? | 16 23 03 | |
| 177 | PRTX | -14 | |
| 178 | GTO7 | 22 07 | |
| 179 | *LBLa | 21 16 11 | |
| 180 | RCLi | 36 45 | |
| 181 | 2 | 02 | |
| 182 | ÷ | -24 | |
| 183 | INT | 16 34 | |
| 184 | STOi | 35 45 | |
| 185 | CLX | -51 | |
| 186 | LSTX | 16-63 | |
| 187 | FRC | 16 44 | |
| 188 | RND | 16 24 | |
| 189 | + | -55 | |
| 190 | RTN | 24 | |
| 191 | *LBLb | 21 16 12 | |
| 192 | CLX | -51 | |
| 193 | 2 | 02 | |
| 194 | R↑ | 16-31 | |
| 195 | $Y^x$ | 31 | |
| 196 | ST+i | 35-55 45 | |
| 197 | RTN | 24 | |
| 198 | *LBLc | 21 16 13 | |
| 199 | GSBd | 23 16 14 | |
| 200 | 0 | 00 | |
| 201 | *LBLC | 21 13 | |
| 202 | RCLi | 36 45 | |
| 203 | X≠0? | 16-42 | |
| 204 | SF3 | 16 21 03 | |
| 205 | X≷Y | -41 | |
| 206 | STOi | 35 45 | |
| 207 | R↓ | -31 | |
| 208 | DSZI | 16 25 46 | |
| 209 | GTOC | 22 13 | |
| 210 | STO0 | 35 00 | |
| 211 | RTN | 24 | |
| 212 | *LBLd | 21 16 14 | |
| 213 | 2 | 02 | |
| 214 | 4 | 04 | |
| 215 | STOI | 35 46 | |
| 216 | RTN | 24 | |
| 217 | *LBLe | 21 16 15 | |
| 218 | R↓ | -31 | |
| 219 | GSBa | 23 16 11 | |
| 220 | LSTX | 16-63 | |
| 221 | X≠0? | 16-42 | |
| 222 | GSBb | 23 16 12 | |
| 223 | RTN | 24 | |

right-shift

downshift

**LABELS**

| | | | | |
|---|---|---|---|---|
| A Start | B | C used | D | E |
| a Sbr. | b Sbr. | c Sbr. | d Sbr. | e Sbr. |
| 0 used | 1 used | 2 used | 3 used | 4 used |
| 5 used | 6 used | 7 used | 8 used | 9 used |

**FLAGS**

| |
|---|
| 0 used |
| 1 used |
| 2 used |
| 3 used |

**SET STATUS**

| FLAGS | | TRIG | | DISP | |
|---|---|---|---|---|---|
| | ON OFF | | | | |
| 0 | ☐ ☒ | DEG | ☐ | FIX | ☒ |
| 1 | ☐ ☒ | GRAD | ☐ | SCI | ☐ |
| 2 | ☐ ☒ | RAD | ☐ | ENG | ☐ |
| 3 | ☐ ☒ | | | n | 0 |

| STEP | KEY ENTRY | KEY CODE | COMMENTS |
|---|---|---|---|
| 001 | *LBLA | 21 11 | Start |
| 002 | DSP2 | -63 02 | |
| 003 | CLRG | 16-53 | |
| 004 | F?S | 16-51 | |
| 005 | CLRG | 16-53 | |
| 006 | 2 | 02 | |
| 007 | 3 | 03 | |
| 008 | STOI | 35 46 | |
| 009 | CLX | -51 | |
| 010 | R/S | 51 | |
| 011 | *LBLB | 21 12 | "0" |
| 012 | DSP0 | -63 00 | |
| 013 | 2 | 02 | |
| 014 | STOi | 35-35 45 | |
| 015 | CLX | -51 | |
| 016 | R/S | 51 | |
| 017 | *LBLC | 21 13 | "1" |
| 018 | DSP0 | -63 00 | |
| 019 | 2 | 02 | |
| 020 | STOi | 35-35 45 | |
| 021 | 1 | 01 | |
| 022 | ST+i | 35-55 45 | |
| 023 | R/S | 51 | |
| 024 | *LBLc | 21 16 13 | decimal no. |
| 025 | DSP0 | -63 00 | |
| 026 | STOi | 35 45 | |
| 027 | R/S | 51 | |
| 028 | *LBLD | 21 14 | "↓" (next line) |
| 029 | DSP9 | -63 09 | |
| 030 | CLX | -51 | |
| 031 | DSZI | 16 25 46 | |
| 032 | R/S | 51 | |
| 033 | ISZI | 16 26 46 | |
| 034 | GTO9 | 22 09 | → 'Error' (↕) |
| 035 | *LBLd | 21 16 14 | clear line |
| 036 | DSP9 | -63 09 | |
| 037 | CLX | -51 | |
| 038 | STOi | 35 45 | |
| 039 | R/S | 51 | |
| 040 | *LBLE | 21 15 | End input |
| 041 | 2 | 02 | |
| 042 | 3 | 03 | |
| 043 | ENT↑ | -21 | |
| 044 | 0 | 00 | |
| 045 | *LBL2 | 21 02 | Shift so that last entered line is sto'd in reg. 0 |
| 046 | RCLi | 36 45 | |
| 047 | 0 | 00 | |
| 048 | STOi | 35 45 | |
| 049 | R↓ | -31 | |
| 050 | X≠Y | -41 | |
| 051 | ISZI | 16 26 46 | |
| 052 | X≠I | 16-41 | |
| 053 | X≠Y | -41 | |
| 054 | STOi | 35 45 | |
| 055 | R↓ | -31 | |
| 056 | X>Y? | 16-34 | |
| 057 | GTOa | 22 16 11 | |
| 058 | ISZI | 16 26 46 | |
| 059 | X≠I | 16-41 | |
| 060 | GTO2 | 22 02 | |
| 061 | *LBLe | 21 16 15 | C↓ (Copy line) |
| 062 | DSP1 | -63 01 | |
| 063 | ISZI | 16 26 46 | |
| 064 | RCLi | 36 45 | |
| 065 | DSZI | 16 25 46 | |
| 066 | STOi | 35 45 | |
| 067 | CLX | -51 | |
| 068 | R/S | 51 | |
| 069 | *LBLa | 21 16 11 | Output (conv. dec.→binary) |
| 070 | SPC | 16-11 | |
| 071 | DSP9 | -63 09 | |
| 072 | 2 | 02 | |
| 073 | 4 | 04 | |
| 074 | STOI | 35 46 | |
| 075 | *LBL3 | 21 03 | register ≠ 0 with maximum index ? |
| 076 | RCLi | 36 45 | |
| 077 | X≠0? | 16-42 | |
| 078 | GTO4 | 22 04 | |
| 079 | DSZI | 16 25 46 | |
| 080 | GTO3 | 22 03 | |
| 081 | *LBL4 | 21 04 | |
| 082 | RCLi | 36 45 | |
| 083 | ENT↑ | -21 | |
| 084 | ENT↑ | -21 | |
| 085 | 1 | 01 | $2^{30}$ |
| 086 | 0 | 00 | |
| 087 | 7 | 07 | |
| 088 | 3 | 03 | |
| 089 | 7 | 07 | |
| 090 | 4 | 04 | |
| 091 | 1 | 01 | |
| 092 | 8 | 08 | |
| 093 | 2 | 02 | |
| 094 | 4 | 04 | |
| 095 | GSB5 | 23 05 | |
| 096 | 1 | 01 | $2^{20}$ |
| 097 | 0 | 00 | |
| 098 | 4 | 04 | |
| 099 | 8 | 08 | |
| 100 | 5 | 05 | |
| 101 | 7 | 07 | |
| 102 | 6 | 06 | |
| 103 | GSB5 | 23 05 | |
| 104 | 1 | 01 | $2^{10}$ |
| 105 | 0 | 00 | |
| 106 | 2 | 02 | |
| 107 | 4 | 04 | |
| 108 | GSB5 | 23 05 | |
| 109 | GSB8 | 23 08 | |
| 110 | SPC | 16-11 | |
| 111 | CF0 | 16 22 00 | |
| 112 | F2? | 16 23 02 | last line ? |

REGISTERS

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0 used | 1 used | 2 used | 3 used | 4 used | 5 used | 6 used | 7 used | 8 used | 9 used |
| S0 used | S1 used | S2 used | S3 used | S4 used | S5 used | S6 used | S7 used | S8 used | S9 used |
| A used | B used | C used | D used | E used | I used | | | | |

# 60173 Program Listing II (2)



| STEP | KEY ENTRY | KEY CODE | COMMENTS |
|---|---|---|---|
| 113 | GTO0 | 22 00 | |
| 114 | DSZI | 16 25 46 | |
| 115 | GTO4 | 22 04 | |
| 116 | SF2 | 16 21 02 | |
| 117 | GTO4 | 22 04 | |
| 118 | *LBL0 | 21 00 | |
| 119 | SFC | 16-11 | |
| 120 | CLX | -51 | |
| 121 | DSP0 | -63 00 | |
| 122 | R/S | 51 | |
| 123 | *LBL5 | 21 05 | |
| 124 | ÷ | -24 | |
| 125 | LSTX | 16-63 | |
| 126 | X≠Y | -41 | |
| 127 | INT | 16 34 | |
| 128 | X=0? | 16-43 | |
| 129 | F0? | 16 23 00 | |
| 130 | GSB6 | 23 06 | |
| 131 | R↓ | -31 | |
| 132 | R↓ | -31 | |
| 133 | ENT↑ | -21 | |
| 134 | RTN | 24 | |
| 135 | *LBL6 | 21 06 | print |
| 136 | SF0 | 16 21 00 | |
| 137 | ENT↑ | -21 | |
| 138 | R↓ | -31 | |
| 139 | x | -35 | |
| 140 | - | -45 | |
| 141 | *LBL8 | 21 08 | |
| 142 | 0 | 00 | |
| 143 | GSB7 | 23 07 | |
| 144 | GSB7 | 23 07 | |
| 145 | GSB7 | 23 07 | |
| 146 | GSB7 | 23 07 | |
| 147 | GSB7 | 23 07 | |
| 148 | GSB7 | 23 07 | |
| 149 | GSB7 | 23 07 | |
| 150 | GSB7 | 23 07 | |
| 151 | GSB7 | 23 07 | |
| 152 | GSB7 | 23 07 | |
| 153 | 2 | 02 | |
| 154 | x | -35 | |
| 155 | PRTX | -14 | |
| 156 | R↑ | 16-31 | |
| 157 | RTN | 24 | |
| 158 | *LBL7 | 21 07 | 1 binary digit |
| 159 | 1 | 01 | |
| 160 | 0 | 00 | |
| 161 | ÷ | -24 | |
| 162 | R↑ | 16-31 | |
| 163 | 2 | 02 | |
| 164 | ÷ | -24 | |
| 165 | FRC | 16 44 | |
| 166 | LSTX | 16-63 | |
| 167 | INT | 16 34 | |
| 168 | R↓ | -31 | |
| 169 | + | -55 | |
| 170 | RTN | 24 | |

## LABELS

| | | | | |
|---|---|---|---|---|
| A Strt Inp | B 0 | C 1 | D ↓ | E End Inp. |
| a Output | b | c dn | d Clr | e C↓ |
| 0 used | 1 | 2 used | 3 used | 4 used |
| 5 Sbr. | 6 Sbr. | 7 Sbr. | 8 Sbr. | 9 |

## FLAGS

| | |
|---|---|
| 0 | used |
| 1 | |
| 2 | used |
| 3 | |

## SET STATUS

| FLAGS | ON | OFF |
|---|---|---|
| 0 | ☐ | ☒ |
| 1 | ☐ | ☐ |
| 2 | ☐ | ☒ |
| 3 | ☐ | ☐ |

| TRIG | |
|---|---|
| DEG | ☐ |
| GRAD | ☐ |
| RAD | ☐ |

| DISP | |
|---|---|
| FIX | ☒ |
| SCI | ☐ |
| ENG | ☐ |
| n | 0 |