Sunday 10th January 1999.

The Big Letters Program (Part 1)

Copies a message on an EDSAC tape into memory a line at a time and then prints each line in big letters on the teleprinter. All lines are terminated by a line-feed except for the final line which is terminated by a blank tape character. The big letters are 5 rows high and vary in width. All characters on the teleprinter may be used (including letter shift and figure shift) except for carriage returns which are ignored. The output of the message "#G*!HELLO!THERE!#G&" is given below.

Example Output:

```
       +-------------------+
       :    BIG LETTERS    :
       :         BY        :
       : MARTIN J. SLUCUTT :
       +-------------------+

YOUR MESSAGE WILL FOLLOW SHORTLY...
LOADING, PLEASE WAIT...

 #  #       H   H  EEEEE  L      L       OOO       TTTTT  H   H  EEEEE  RRRR   EEEEE       #  #
######      H   H  E      L      L      O   O        T    H   H  E      R   R  E           ######
 #  #       HHHHH  EEE    L      L      O   O        T    HHHHH  EEE    RRRR   EEE          #  #
######      H   H  E      L      L      O   O        T    H   H  E      R  R   E           ######
 #  #       H   H  EEEEE  LLLLL  LLLLL   OOO         T    H   H  EEEEE  R   R  EEEEE       #  #
```

Make-up of the Program Tape:

```
space P K

T56K
```

M3

```
@&#!!!!!!!ZAAAAAAAAAAAAAAAAAAAZ*
@&#!!!!!!!C*!!!!BIG!LETTERS!!!!#C*
@&#!!!!!!!C*!!!!!!!!!BY!!!!!!!!#C*
@&#!!!!!!!C*!MARTIN!J#M*!SLUCUTT!#C*
@&#!!!!!!!ZAAAAAAAAAAAAAAAAAAAZ*
@&
@&*YOUR!MESSAGE!WILL!FOLLOW!SHORTLY#MMM*
@&*LOADING#N*!PLEASE!WAIT#MMM*
@&
@&

space P Z

T56K
```

Master

```
E137K P F
```

The master routine is made-up of the following parts:

Section of Master Routine	Location
Subroutine MS1 prints a single row of a big letter. The location of the letter in memory is given as a parameter in location 4F	θ
Subroutine MS2 reads characters on an EDSAC tape into the memory location specified by the C parameter upwards, stopping when a line-feed or blank tape character is read	49θ
Main routine	81θ
Variables	M
Constants	Δ
Big letter widths and bit patterns	V

Notes:

- The program needs to test for the equality of two memory locations and this could not be avoided. The following routine was developed to test the equality of 2M and 6M, for example:

```
63 |  .   .. . |
64 |  .   .. . |
65 |  T      F |  Clear accumulator (if required)
66 |  A    2 M |  Calculate difference between two values
67 |  S    6 M |
68 |  G   80 θ |  Branch if negative (not equal)
69 |  S      Δ |  Subtract 1 (stored in location Δ)
70 |  E   80 θ |  Branch if positive (not equal)
71 |  T      F |  Two values are equal (Acc. was 0 at 68 and -1 at 70)
72 |  .   .. . |  Routine if equal
.. |  .   .. . |
.. |  .   .. . |
80 |  .   .. . |  Routine if not equal
81 |  .   .. . |
```

- With the output of the teleprinter as shown below for the message “HELLO&”, the variables would be as follows:

```
H    H   EEEEE   L         L          OOO
H    H   E       L         L        O    O
HHH
```

Teleprinter position

M	= -3	Row count: initially = -5, finally = 0.
1M	= HF	Output character (H).
2M	= ϕF	Space character.
3M	= -4	Width count: initially = -7, finally = 0. (Initially = negative width of big letter including gap afterwards).
4M	= &89F (1100...)	Remaining bit pattern: initially = 01111100....
5M	= 5	Input character count (number of characters in the current line).
6M	= 24	Last input character (value of line-feed in this example).
7M	= 1	Output character count (The first character is being printed on the row).
8M	= 0	= 0 for letter shift, = 1 for figure shift.

The Big Letters Program (Part 2)

The Master Tape:

```
                 G      K
                 T   47 K   ] Set M parameter
                 P  139 θ   ]
                 P  148 θ     Set Δ parameter
                 T   54 K   ] Set C parameter
                 P  470 θ   ]
                 P  162 θ     Set V parameter
                 T      Z
98 → 0           A    3 F   ] Plant link
       1         T   48 θ   ]
       2         A    4 F   ] (Get parameter, p from 4F)
       3         A    2 Δ   ] Form A p F to get output character
       4         T    5 θ   ]
       5        (A      C)    Becomes A p F/D
       6         U    1 M   ] Form S w F to get character width, where
       7         L    2 F   ]     w = ((character value * 8) + V + status)
       8         A    8 M   ] (Adjust if figure shift)
       9         L      D   ] (Shift left for address)
      10         A   55 F   ]
      11         A    3 Δ   ]
      12         T   13 θ   ]
      13        (S      V)    Becomes S w F
      14         E   48 θ     Jump to 48 - Character width is 0
      15         T    3 M     Set width counter
      16         A    1 M   ]
      17         L    2 F   ] Form A b F/D to get bit pattern, where
      18         A      M   ]     b = ((character value * 8) + row count + 7)
      19         A    7 Δ   ]
      20         L      D   ] (Shift left for address)
      21         A   55 F   ]
      22         A    2 Δ   ]
      23         T   24 θ   ]
      24        (A      V)    Becomes A b F/D
      25         T    4 M     Set bit pattern
      26         S    8 M     Get status
      27         E   32 θ     Jump to 32 - In letter shift mode
      28         T      F   ]
      29         A    4 M   ] In figure shift mode so shift bit pattern 8 bits
      30         L   64 F   ]
      31         T    4 M   ]
27 → 32          A    1 M   ]
      33         L 1024 F   ] Shift output character for printing
      34         T    1 M   ]
47 → 35          T      F   ]                                                  ]
      36         A    4 M   ] Left shift line code by 1 bit                    ]
      37         L      D   ]                                                  ]
      38         U    4 M   ]                                                  ]
      39         G   42 θ     Jump to 42 - Bit pattern is 1...                 ]
      40         O    2 M     Space (Bit pattern is 0...)                      ] (d)
      41         E   43 θ     Jump to 43                                       ]
                 ----------                                                    ]
39 → 42          O    1 M     Output character                                 ]
41 → 43          T      F   ]                                                  ]
      44         A    3 M   ] Increment width counter                          ]
```

```
          45 |  A      Δ |
          46 |  U    3 M |  (d)
          47 |  G   35 θ |  Repeat to output remaining character row
    14 → 48 | (E       F)|
            |------------|
    86 → 49 |  A    3 F |  Plant link
          50 |  T   80 θ |
          51 |  T    5 M |  Set input character count to zero
    79 → 52 |  A    5 M |
          53 |  L      D |  (Left shift for address)
          54 |  A   54 F |  Form T i F/D to transfer input character,
          55 |  A    1 Δ |      where i = (C + input character count)
          56 |  T   75 θ |
          57 |  I    6 M |  Read character from tape
          58 |  A    6 M |  Check if input character is a blank tape
          59 |  S    4 Δ |      character
          60 |  G   65 θ |  (Jump to 65 - No blank tape)
          61 |  S      Δ |
          62 |  E   65 θ |  (Jump to 65 - No blank tape)
          63 |  T      F |  (Input character is a blank tape character)
          64 |  E   80 θ |  Jump to 80
            |------------|
60,62 → 65 |  T      F |                                              (e)
          66 |  A    6 M |  Check if input character is a line-feed
          67 |  S    5 Δ |
          68 |  G   73 θ |  (Jump to 73 - No line-feed)
          69 |  S      Δ |
          70 |  E   73 θ |  (Jump to 73 - No line-feed)
          71 |  T      F |  (Input character is a line-feed)
          72 |  E   80 θ |
            |------------|
68,70 → 73 |  T      F |  Set (C + input character count) to input
          74 |  A    6 M |      character
          75 | (T      C)|  (Becomes T i F/D)
          76 |  A    5 M |
          77 |  A      Δ |  Increment input character count
          78 |  T    5 M |
          79 |  E   52 θ |  Repeat to read next character on tape
            |------------|
64,72 → 80 | (E       F)|
            |------------|
 Enter → 81 |  X      F |  No order[1]
134,
  136 → 82 |  T      F |
          83 |  S    6 Δ |  Set row count to -5
          84 |  T      M |
          85 |  A   85 θ |  Read line from tape
          86 |  G   49 θ |      using subroutine MS2
MS2,        |------------|
  129 → 87 |  T      F |  Set output character count to 0                 (c)
          88 |  T    7 M |
  123 → 89 |  A    7 M |  Calculate number bit patterns                (b)
          90 |  S    5 M |      remaining to output on current row
          91 |  E  124 θ |  Jump to 124 - None remaining
          92 |  T      F |  Calculate location of next                (a)
          93 |  A    7 M |      output character
          94 |  L      D |  (Shift left for address)
          95 |  A   54 F |
          96 |  T    4 F |  Set 4F as parameter for MS1
```

```
          97    A   97 θ   Print row of character
          98    G      θ       using subroutine MS1
                ------------
 MS1 →    99    T      F
         100    A    1 M   Check if output character
         101    S    9 Δ       is a figure shift
         102    G  110 θ   (Jump to 110 - No figure shift)
         103    S      Δ
         104    E  110 θ   (Jump to 110 - No figure shift)
         105    T      F   (Output character is a figure shift)
         106    A      Δ   Set status to 1
         107    T    8 M
         108    O   11 Δ     Figure shift
         109    E  119 θ     Jump to 119                          (a)
102,
 104 →   110    T      F
         111    A    1 M   Check if output character                    (b)
         112    S    J Δ       is a letter shift
         113    G  119 θ   (Jump to 119 - No letter shift)
         114    S      Δ
         115    E  119 θ   (Jump to 119 - No letter shift)                    (c)
         116    T      F   (Output character is a letter shift)
         117    T    8 M   Set status to 0
         118    O   12 Δ     Letter shift
109,113
 115 →   119    T      F
         120    A    7 M   Increment output character count
         121    A      Δ
         122    T    7 M
         123    E   89 θ     Repeat output bit pattern cycle
                ------------
  91 →   124    O    8 Δ     Line-feed
         125    O   13 &     CR
         126           F
         127    A      M      Increment row counter
         128    A      Δ
         129    U      M
         130    G   87 θ      Repeat output row cycle
         131    O    8 Δ      Line-feed
         132    O   13 &      CR
         133    A    6 M      Check if last input character
         134    S    4 Δ          is a blank tape character
         135    G   82 θ      (Repeat main routine - no blank tape)
         136    S      Δ
         137    E   82 θ      (Repeat main routine - no blank tape)
         138    Z      F      Stop

       M 0      P      F     Row count
         1      P      F     Output character
         2      ϕ      F     Space
         3      P      F     Width count
         4      P      F     Bit pattern
         5      P      F     Input character count
         6      P      F     Last input character
         7      P      F     Output character count
         8      P      F     = 0 (= 0 for letter shift, = 1 for figure shift)

       Δ 0      P      D     = 1
         1      T      F     Transfer order
         2      A      F     Add order
```

```
    3 ||| S       F |  Subtract order
    4 ||| P     8 F |  = 16 (Value of blank tape)
    5 ||| P    12 F |  = 24 (Value of line-feed)
    6 ||| P     2 D |  = 5
    7 ||| P     3 D |  = 7
    8 ||| Δ       F |  Line-feed
    9 ||| P     5 D |  = 11 (Value of figure shift)
   10 ||| P     7 D |  = 15 (Value of letter shift)
   11 ||| π       F |  Figure shift
   12 ||| *       F |  Letter shift
   13 ||| @       F |  CR

V  0  ||| P     3 D |  = 7 (Width of P)
   1  ||| P     3 D |  = 7 (Width of 0)
   2  ||| *    56 F |  ( 1111     111     )
   3  ||| I 1100 F |  ( 1   1   1  11    )
   4  ||| *    84 F |  ( 1111    1 1 1    )
   5  ||| I   100 F |  ( 1       11  1    )
   6  ||| I    56 F |  ( 1        111     )
   7  ||| P       F |

   8  ||| P     3 D |  = 7 (Width of Q)
   9  ||| P     2 F |  = 4 (Width of 1)
  10  ||| U    32 F |  (  111     1       )
  11  ||| I 1120 F |  ( 1   1   11       )
  12  ||| J 1056 F |  ( 1 1 1    1       )
  13  ||| O    32 F |  ( 1  1     1       )
  14  ||| Y 1056 F |  (  11 1    1       )
  15  ||| P       F |

  16  ||| P     3 D |  = 7 (Width of W)
  17  ||| P     3 D |  = 7 (Width of 2)
  18  ||| I 1080 F |  ( 1   1    111     )
  19  ||| I 1092 F |  ( 1   1   1   1    )
  20  ||| J 1048 F |  ( 1 1 1     11     )
  21  ||| J 1056 F |  ( 1 1 1    1       )
  22  ||| T  124 F |  (  1 1    11111    )
  23  ||| P       F |

  24  ||| P     3 D |  = 7 (Width of E)
  25  ||| P     3 D |  = 7 (Width of 3)
  26  ||| * 1080 F |  ( 11111    111     )
  27  ||| I   68 F |  ( 1       1   1    )
  28  ||| K   24 F |  ( 111       11     )
  29  ||| I   68 F |  ( 1       1   1    )
  30  ||| * 1080 F |  ( 11111    111     )
  31  ||| P       F |

  32  ||| P     3 D |  = 7 (Width of R)
  33  ||| P     3 D |  = 7 (Width of 4)
  34  ||| *   24 F |  ( 1111      11     )
  35  ||| I 1064 F |  ( 1   1    1 1     )
  36  ||| *  124 F |  ( 1111    11111    )
  37  ||| O    8 F |  ( 1  1       1     )
  38  ||| I 1032 F |  ( 1   1      1     )
  39  ||| P       F |

  40  ||| P     3 D |  = 7 (Width of T)
  41  ||| P     3 D |  = 7 (Width of 5)
  42  ||| * 1148 F |  ( 11111   11111    )
  43  ||| W   64 F |  (   1     1        )
  44  ||| W  120 F |  (   1     1111     )
  45  ||| W    4 F |  (   1         1    )
  46  ||| W  120 F |  (   1     1111     )
  47    P       F
```

```
 48 | P    3 D   | = 7 (Width of Y)
 49 | P    3 D   | = 7 (Width of 6)
 50 | I 1084 F   | ( 1   1    1111    )
 51 | T   64 F   | (  1 1    1        )
 52 | W  120 F   | (   1     1111     )
 53 | W   68 F   | (   1     1   1    )
 54 | W   56 F   | (   1      111     )
 55 | P      F   |

 56 | P    3 D   | = 7 (Width of U)
 57 | P    3 D   | = 7 (Width of 7)
 58 | I 1148 F   | ( 1   1   11111    )
 59 | I 1028 F   | ( 1   1       1    )
 60 | I 1032 F   | ( 1   1      1     )
 61 | I 1040 F   | ( 1   1     1      )
 62 | U   32 F   | (  111     1       )
 63 | P      F   |

 64 | P    1 D   | = 3 (Width of I)
 65 | P    3 D   | = 7 (Width of 8)
 66 | I   56 F   | ( 1        111     )
 67 | I   68 F   | ( 1       1   1    )
 68 | I   56 F   | ( 1        111     )
 69 | I   68 F   | ( 1       1   1    )
 70 | I   56 F   | ( 1        111     )
 71 | P      F   |

 72 | P    3 D   | = 7 (Width of O)
 73 | P    3 D   | = 7 (Width of 9)
 74 | U   56 F   | (  111     111     )
 75 | I 1092 F   | ( 1   1   1   1    )
 76 | I 1084 F   | ( 1   1    1111    )
 77 | I 1028 F   | ( 1   1       1    )
 78 | U  120 F   | (  111    1111     )
 79 | P      F   |

 80 | P    3 D   | = 7 (Width of J)
 81 | P      F   | = 0 (No character)
 82 | * 1024 F   | ( 11111            )
 83 | W      F   | (   1              )
 84 | W      F   | (   1              )
 85 | J      F   | ( 1 1              )
 86 | R      F   | (  1               )
 87 | P      F   |

 88 | P      F   | = 0 (Figure shift)
 89 | P      F   | = 0 (Figure shift)
 90 | P      F   | (                  )
 91 | P      F   | (                  )
 92 | P      F   | (                  )
 93 | P      F   | (                  )
 94 | P      F   | (                  )
 95 | P      F   |

 96 | P    3 D   | = 7 (Width of S)
 97 | P    2 D   | = 5 (Width of ")
 98 | U 1104 F   | (  1111   1 1      )
 99 | I   80 F   | ( 1       1 1      )
100 | U      F   | (  111             )
101 | P 1024 F   | (     1            )
102 | *      F   | ( 1111             )
103 | P      F   |
```

```
104 ‖ P    3 D ‖ = 7 (Width of Z)
105 ‖ P    3 D ‖ = 7 (Width of +)
106 ‖ * 1024 F ‖ ( 11111            )
107 ‖ Q   16 F ‖ (    1      1      )
108 ‖ W  124 F ‖ (   1     11111    )
109 ‖ R   16 F ‖ (  1        1      )
110 ‖ * 1024 F ‖ ( 11111            )
111 ‖ P      F ‖
    ‖         ‖
112 ‖ P    3 D ‖ = 7 (Width of K)
113 ‖ P    2 F ‖ = 4 (Width of '(')
114 ‖ I 1056 F ‖ ( 1   1    1        )
115 ‖ π   64 F ‖ ( 1 11    1         )
116 ‖ S   64 F ‖ ( 11      1         )
117 ‖ π   64 F ‖ ( 1 11    1         )
118 ‖ I 1056 F ‖ ( 1   1    1        )
119 ‖ P      F ‖
    ‖         ‖
120 ‖ P      F ‖ = 0 (Letter shift)
121 ‖ P      F ‖ = 0 (Letter shift)
122 ‖ P      F ‖ (                  )
123 ‖ P      F ‖ (                  )
124 ‖ P      F ‖ (                  )
125 ‖ P      F ‖ (                  )
126 ‖ P      F ‖ (                  )
127 ‖ P      F ‖
    ‖         ‖
128 ‖ P      F ‖ = 0 (Blank tape)
129 ‖ P      F ‖ = 0 (Blank tape)
130 ‖ P      F ‖ (                  )
131 ‖ P      F ‖ (                  )
132 ‖ P      F ‖ (                  )
133 ‖ P      F ‖ (                  )
134 ‖ P      F ‖ (                  )
135 ‖ P      F ‖
    ‖         ‖
136 ‖ P    3 D ‖ = 7 (Width of F)
137 ‖ P    3 D ‖ = 7 (Width of $)
138 ‖ * 1084 F ‖ ( 11111    1111    )
139 ‖ I   80 F ‖ ( 1       1 1      )
140 ‖ K   56 F ‖ ( 111      111     )
141 ‖ I   20 F ‖ ( 1         1 1    )
142 ‖ I  120 F ‖ ( 1       1111     )
143 ‖ P      F ‖
    ‖         ‖
144 ‖ P      F ‖ = 0 (Carriage return)
145 ‖ P      F ‖ = 0 (Carriage return)
146 ‖ P      F ‖ (                  )
147 ‖ P      F ‖ (                  )
148 ‖ P      F ‖ (                  )
149 ‖ P      F ‖ (                  )
150 ‖ P      F ‖ (                  )
151 ‖ P      F ‖
    ‖         ‖
152 ‖ P    3 D ‖ = 7 (Width of D)
153 ‖ P    2 D ‖ = 5 (Width of ;)
154 ‖ *      F ‖ ( 1111             )
155 ‖ I 1072 F ‖ ( 1   1    11      )
156 ‖ I 1024 F ‖ ( 1   1            )
157 ‖ I 1072 F ‖ ( 1   1    11      )
158 ‖ *   96 F ‖ ( 1111    11       )
159 ‖ P      F ‖
    ‖         ‖
160 ‖ P    2 F ‖ = 5 (Width of space)
```

```
161 ||  P    2 F  |  = 5 (Width of space)
162 ||  P      F  |  (                   )
163 ||  P      F  |  (                   )
164 ||  P      F  |  (                   )
165 ||  P      F  |  (                   )
166 ||  P      F  |  (                   )
167 ||  P      F  |
168 ||  P    3 D  |  = 7 (Width of H)
169 ||  P    3 D  |  = 7 (Width of £)
170 ||  I 1052 F  |  ( 1   1     111    )
171 ||  I 1056 F  |  ( 1   1    1       )
172 ||  * 1144 F  |  ( 11111   1111     )
173 ||  I 1056 F  |  ( 1   1    1       )
174 ||  I 1148 F  |  ( 1   1   11111    )
175 ||  P      F  |
176 ||  P    3 D  |  = 7 (Width of N)
177 ||  P    2 D  |  = 5 (Width of ,)
178 ||  I 1024 F  |  ( 1   1            )
179 ||  S 1024 F  |  ( 11  1            )
180 ||  J 1024 F  |  ( 1 1 1            )
181 ||  O 1072 F  |  ( 1  11    11      )
182 ||  I 1120 F  |  ( 1   1   11       )
183 ||  P      F  |
184 ||  P    3 D  |  = 7 (Width of M)
185 ||  P    2 F  |  = 4 (Width of .)
186 ||  I 1024 F  |  ( 1   1            )
187 ||  Z 1024 F  |  ( 11 11            )
188 ||  J 1024 F  |  ( 1 1 1            )
189 ||  I 1120 F  |  ( 1   1   11       )
190 ||  I 1120 F  |  ( 1   1   11       )
191 ||  P      F  |
192 ||  P      F  |  = 0 (Line-feed)
193 ||  P      F  |  = 0 (Line-feed)
194 ||  P      F  |  (                   )
195 ||  P      F  |  (                   )
196 ||  P      F  |  (                   )
197 ||  P      F  |  (                   )
198 ||  P      F  |  (                   )
199 ||  P      F  |
200 ||  P    3 D  |  = 7 (Width of L)
201 ||  P    2 F  |  = 4 (Width of ')')
202 ||  I   64 F  |  ( 1       1        )
203 ||  I   32 F  |  ( 1        1       )
204 ||  I   32 F  |  ( 1        1       )
205 ||  I   32 F  |  ( 1        1       )
206 ||  * 1088 F  |  ( 11111   1        )
207 ||  P      F  |
208 ||  P    3 D  |  = 7 (Width of X)
209 ||  P    3 D  |  = 7 (Width of /)
210 ||  I 1028 F  |  ( 1   1       1    )
211 ||  T    8 F  |  (  1 1       1     )
212 ||  W   16 F  |  (   1       1      )
213 ||  T   32 F  |  (  1 1     1       )
214 ||  I 1088 F  |  ( 1   1   1        )
215 ||  P      F  |
216 ||  P    4 F  |  = 8 (Width of G)
217 ||  P    4 F  |  = 8 (Width of #)
```

```
218    U 1060 F     (  1111    1  1    )
219    I  126 F     ( 1       111111   )
220    I 1572 F     ( 1   11   1  1    )
221    I  638 F     ( 1    1  111111   )
222    U 1060 F     (  1111    1  1    )
223    P      F

224    P    3 D     = 7 (Width of A)
225    P    3 D     = 7 (Width of -)
226    U      F     (  111             )
227    I 1024 F     ( 1   1            )
228    * 1148 F     ( 11111   11111    )
229    I 1024 F     ( 1   1            )
230    I 1024 F     ( 1   1            )
231    P      F

232    P    3 D     = 7 (Width of B)
233    P    3 D     = 7 (Width of ?)
234    *   56 F     ( 1111     111     )
235    I 1092 F     ( 1   1   1   1    )
236    *    8 F     ( 1111       1     )
237    I 1024 F     ( 1   1            )
238    *   16 F     ( 1111      1      )
239    P      F

240    P    3 F     = 6 (Width of C)
241    P    2 F     = 4 (Width of :)
242    U      F     (  111             )
243    I   96 F     ( 1       11       )
244    I      F     ( 1                )
245    I   96 F     ( 1       11       )
246    U      F     (  111             )
247    P      F

248    P    3 D     = 7 (Width of V)
249    P    3 D     = 7 (Width of =)
250    I 1024 F     ( 1   1            )
251    I 1148 F     ( 1   1   11111    )
252    I 1024 F     ( 1   1            )
253    T  124 F     (  1 1    11111    )
254    W      F     (   1              )
255    P      F

256    E  137 K   ] Enter at location 81θ
257    P      F   ]
```

a) Cycle to print a row of a character.
b) Cycle to print an entire row.
c) Cycle to print a line of the message.
d) Cycle to output each individual letter/space of a row of character.
e) Cycle to input a line of the message.

Notes:

1) Change to Z F to stop at beginning of the program and step through to check program.ing Z F to check program