Foundations2
Assignment 2020
Turing Machine multiplier

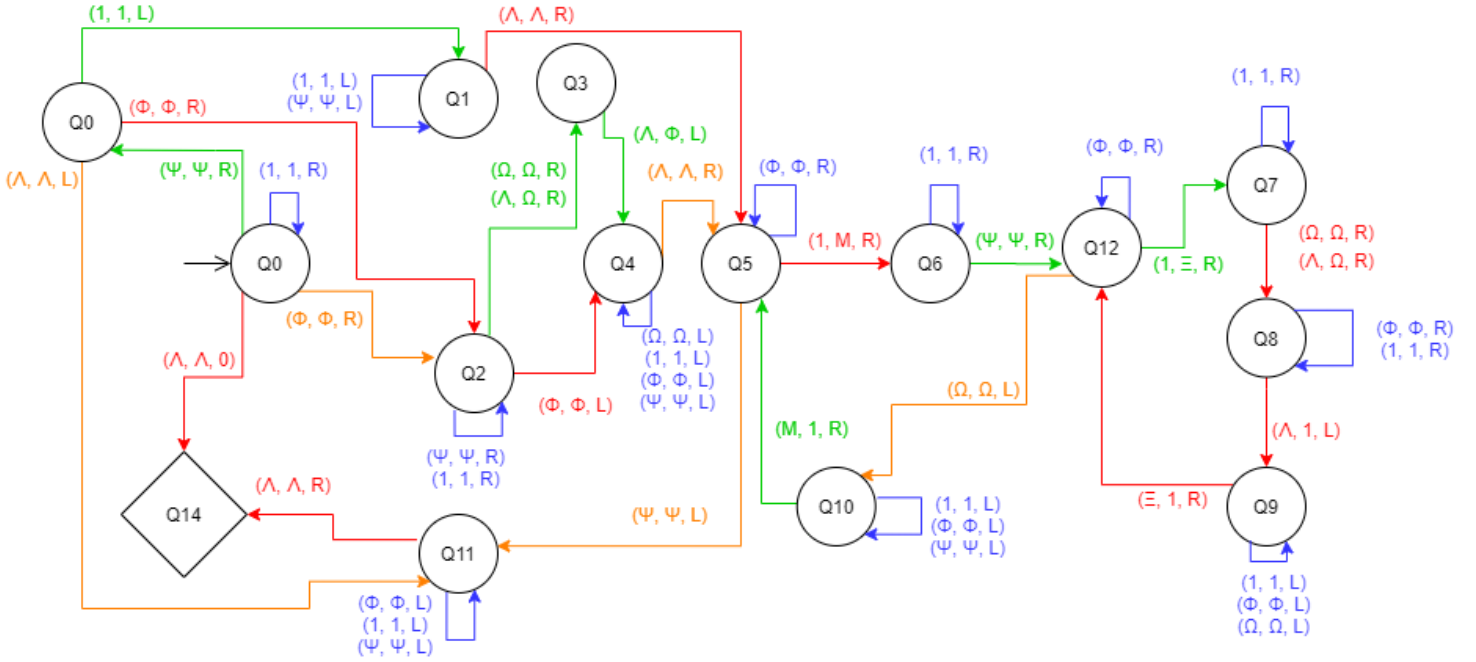Sam Fay-Hunt `sf52@hw.ac.uk`

Contents

1 Turing machine multiplication

1.1 Graph

(1, 1, L) (Λ, Λ, R) (1, 1, R)

Q0

(1, 1, L)
(Ψ, Ψ, L)   Q1   Q3

(Φ, Φ, R)

(Λ, Φ, L)

(Φ, Φ, R)

(1, 1, R)   (Φ, Φ, R)   Q7

(Λ, Λ, L)

(Ψ, Ψ, R) (1, 1, R)   (Ω, Ω, R)
(Λ, Ω, R)   (Λ, Λ, R)   (1, M, R)   (Ψ, Ψ, R)   Q12

Q0

(Ω, Ω, R)
(Λ, Ω, R)

Q4   Q5   Q6   (1, Ξ, R)

(Φ, Φ, R)

(Ω, Ω, R)
(Λ, Ω, R)

Q8   (Φ, Φ, R)
(1, 1, R)

(Λ, Λ, 0)

Q2

(Ω, Ω, L)
(1, 1, L)
(Φ, Φ, L)   (Ω, Ω, L)
(Φ, Φ, L)   (Ψ, Ψ, L)

(M, 1, R)

(Λ, 1, L)

(Ψ, Ψ, R)
(1, 1, R)

(Λ, Λ, R)

Q14   (Ψ, Ψ, L)   Q10   (1, 1, L)   (Ξ, 1, R)   Q9
(Φ, Φ, L)
(Ψ, Ψ, L)

Q11

(Φ, Φ, L)
(1, 1, L)
(Ψ, Ψ, L)

(1, 1, L)
(Φ, Φ, L)
(Ω, Ω, L)

1.2 Formal definition

The following is the formal definition of the multiplier machine with negative numbers.

$$States = \{q_0, q_1, q_2, q_3, q_4, q_5, q_6, q_7, q_8, q_9, q_{10}, q_{11}, q_{12}\}$$

$Symbols = \{\wedge, \Phi, \Psi, \Omega, 1, M, \Xi\}$

$$M_{mult}(q_0, \wedge) = (q_{12}, \wedge, 0) \qquad M_{mult}(q_0, 1) = (q_0, 1, R)$$
$$M_{mult}(q_0, \Psi) = (q_1, \Psi, R) \qquad M_{mult}(q_0, \Phi) = (q_2, \Phi, R)$$
$$M_{mult}(q_1, 1) = (q_1, 1, L) \qquad M_{mult}(q_1, \Psi) = (q_1, \Psi, L)$$
$$M_{mult}(q_1, \wedge) = (q_5, \wedge, R) \qquad M_{mult}(q_1, \Phi) = (q_2, \Phi, R)$$
$$M_{mult}(q_2, 1) = (q_2, 1, R) \qquad M_{mult}(q_2, \Psi) = (q_2, \Psi, R)$$
$$M_{mult}(q_2, \wedge) = (q_3, \Omega, R) \qquad M_{mult}(q_2, \Omega) = (q_3, \Omega, R)$$
$$M_{mult}(q_2, \Phi) = (q_4, \Phi, L) \qquad M_{mult}(q_3, \wedge) = (q_4, \Phi, L)$$
$$M_{mult}(q_4, \Omega) = (q_4, \Omega, L) \qquad M_{mult}(q_4, 1) = (q_4, 1, L)$$
$$M_{mult}(q_4, \Phi) = (q_4, \Phi, L) \qquad M_{mult}(q_4, \Psi) = (q_4, \Psi, L)$$
$$M_{mult}(q_4, \wedge) = (q_5, \wedge, R) \qquad M_{mult}(q_5, \Phi) = (q_5, \Phi, R)$$
$$M_{mult}(q_5, 1) = (q_6, M, R) \qquad M_{mult}(q_5, \Psi) = (q_{11}, \Psi, L)$$
$$M_{mult}(q_6, \Phi) = (q_6, \Phi, R) \qquad M_{mult}(q_6, \Psi) = (q_6, \Psi, R)$$
$$M_{mult}(q_6, 1) = (q_7, \Xi, R) \qquad M_{mult}(q_6, \Omega) = (q_{10}, \Omega, L)$$
$$M_{mult}(q_7, \Omega) = (q_8, \Omega, R) \qquad M_{mult}(q_7, \wedge) = (q_8, \Omega, R)$$
$$M_{mult}(q_7, 1) = (q_7, 1, R) \qquad M_{mult}(q_8, \wedge) = (q_9, 1, L)$$
$$M_{mult}(q_8, 1) = (q_8, 1, R) \qquad M_{mult}(q_8, \Phi) = (q_8, \Phi, R)$$
$$M_{mult}(q_9, 1) = (q_9, 1, L) \qquad M_{mult}(q_9, \Phi) = (q_9, \Phi, L)$$
$$M_{mult}(q_9, \Omega) = (q_9, \Omega, L) \qquad M_{mult}(q_9, \Xi) = (q_6, 1, R)$$
$$M_{mult}(q_{10}, 1) = (q_{10}, 1, L) \qquad M_{mult}(q_{10}, \Phi) = (q_{10}, \Phi, L)$$
$$M_{mult}(q_{10}, \Psi) = (q_{10}, \Psi, L) \qquad M_{mult}(q_{10}, M) = (q_5, 1, R)$$
$$M_{mult}(q_{11}, 1) = (q_{11}, 1, L) \qquad M_{mult}(q_{11}, \Phi) = (q_{11}, \Phi, L)$$
$$M_{mult}(q_{11}, \wedge) = (q_{12}, \wedge, R)$$

2 Discussion of graph

2.1 Logic of graph

describe the logic of the graph, why I chose this logical method. consider the correctness.

Initially the Graph determines if either, or both, of the pair of numbers on the existing tape are negative.

2.2 States & Symbols

Why I chose these states and symbols blah cut down version here

3 TM functionality

How the graph works, where to start, where you end and dealing with 0, and negative numbers

4 Implementation of Turing machine

Language choice

5 Tests

Tests, inlcuding count of tapes printed, time to complete test

5.1 Quick summary

I have included a few tests on the following pages to demonstrate, basic functionality and corner cases.

Tests with tapes included in this document,

Test name	Time(ms)	Tapes
2×2	3	65
-1×5	4	111

5.2 2 x 2

Number of tapes: 65
Tape execution time: 3ms

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	1	Ψ	1	1	∧	∧	∧	∧	∧	∧	...

↑
$q0$

Tape number: 0

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	1	Ψ	1	1	∧	∧	∧	∧	∧	∧	...

↑
$q0$

Tape number: 1

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	1	Ψ	1	1	∧	∧	∧	∧	∧	∧	...

↑
$q0$

Tape number: 2

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	1	Ψ	1		1	∧	∧	∧	∧	∧	∧	...

↑
$q13$

Tape number: 3

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	1	Ψ	1	1	∧	∧	∧	∧	∧	∧	...

↑
$q1$

Tape number: 4

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	1	Ψ	1	1	∧	∧	∧	∧	∧	∧	...

↑
$q1$

Tape number: 5

5

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	1	Ψ	1	1	∧	∧	∧	∧	∧	∧	...

↑
q1

Tape number: 6

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	1	Ψ	1	1	∧	∧	∧	∧	∧	∧	...

↑
q1

Tape number: 7

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	1	Ψ	1	1	∧	∧	∧	∧	∧	∧	...

↑
q5

Tape number: 8

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	M	1	Ψ	1	1	∧	∧	∧	∧	∧	∧	...

↑
q6

Tape number: 9

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	M	1	Ψ	1	1	∧	∧	∧	∧	∧	∧	...

↑
q6
Tape number: 10

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	M	1	Ψ	1	1	∧	∧	∧	∧	∧	∧	...

↑
q12
Tape number: 11

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	M	1	Ψ	Ξ	1	∧	∧	∧	∧	∧	∧	...

↑
$q7$
Tape number: 12

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	M	1	Ψ	Ξ	1	∧	∧	∧	∧	∧	∧	...

↑
$q7$
Tape number: 13

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	M	1	Ψ	Ξ	1	Ω	∧	∧	∧	∧	∧	...

↑
$q8$
Tape number: 14

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	M	1	Ψ	Ξ	1	Ω	1	∧	∧	∧	∧	...

↑
$q9$
Tape number: 15

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	M	1	Ψ	Ξ	1	Ω	1	∧	∧	∧	∧	...

↑
$q9$
Tape number: 16

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	M	1	Ψ	Ξ	1	Ω	1	∧	∧	∧	∧	...

↑
$q9$
Tape number: 17

	-2	-1	0	1	2	3	4	5	6	7	8	9	10
...	$\wedge$	$\wedge$	M	1	Ψ	1	1	Ω	1	$\wedge$	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$
$q12$

Tape number: 18

	-2	-1	0	1	2	3	4	5	6	7	8	9	10
...	$\wedge$	$\wedge$	M	1	Ψ	1	Ξ	Ω	1	$\wedge$	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$
$q7$

Tape number: 19

	-2	-1	0	1	2	3	4	5	6	7	8	9	10
...	$\wedge$	$\wedge$	M	1	Ψ	1	Ξ	Ω	1	$\wedge$	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$
$q8$

Tape number: 20

	-2	-1	0	1	2	3	4	5	6	7	8	9	10
...	$\wedge$	$\wedge$	M	1	Ψ	1	Ξ	Ω	1	$\wedge$	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$
$q8$

Tape number: 21

	-2	-1	0	1	2	3	4	5	6	7	8	9	10
...	$\wedge$	$\wedge$	M	1	Ψ	1	Ξ	Ω	1	1	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$
$q9$

Tape number: 22

	-2	-1	0	1	2	3	4	5	6	7	8	9	10
...	$\wedge$	$\wedge$	M	1	Ψ	1	Ξ	Ω	1	1	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$
$q9$

Tape number: 23

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	$\wedge$	$\wedge$	M	1	Ψ	1	Ξ	Ω	1	1	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$

$q9$

Tape number: 24

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	$\wedge$	$\wedge$	M	1	Ψ	1	1	Ω	1	1	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$

$q12$

Tape number: 25

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	$\wedge$	$\wedge$	M	1	Ψ	1	1	Ω	1	1	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$

$q10$

Tape number: 26

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	$\wedge$	$\wedge$	M	1	Ψ	1	1	Ω	1	1	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$

$q10$

Tape number: 27

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	$\wedge$	$\wedge$	M	1	Ψ	1	1	Ω	1	1	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$

$q10$

Tape number: 28

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	$\wedge$	$\wedge$	M	1	Ψ	1	1	Ω	1	1	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$

$q10$

Tape number: 29

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	M	1	Ψ	1	1	Ω	1	1	∧	∧	∧	...

↑
$q10$

Tape number: 30

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	1	Ψ	1	1	Ω	1	1	∧	∧	∧	...

↑
$q5$

Tape number: 31

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	1	1	Ω	1	1	∧	∧	∧	...

↑
$q6$
Tape number: 32

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	1	1	Ω	1	1	∧	∧	∧	...

↑
$q12$
Tape number: 33

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	Ξ	1	Ω	1	1	∧	∧	∧	...

↑
$q7$
Tape number: 34

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	Ξ	1	Ω	1	1	∧	∧	∧	...

↑
$q7$
Tape number: 35

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	Ξ	1	Ω	1	1	∧	∧	∧	...

↑
$q8$

Tape number: 36

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	Ξ	1	Ω	1	1	∧	∧	∧	...

↑
$q8$

Tape number: 37

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	Ξ	1	Ω	1	1	∧	∧	∧	...

↑
$q8$

Tape number: 38

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	Ξ	1	Ω	1	1	1	∧	∧	...

↑
$q9$

Tape number: 39

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	Ξ	1	Ω	1	1	1	∧	∧	...

↑
$q9$

Tape number: 40

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	Ξ	1	Ω	1	1	1	∧	∧	...

↑
$q9$

Tape number: 41

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	Ξ	1	Ω	1	1	1	∧	∧	...

↑
$q9$

Tape number: 42

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	Ξ	1	Ω	1	1	1	∧	∧	...

↑
$q9$

Tape number: 43

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	1	1	Ω	1	1	1	∧	∧	...

↑
$q12$

Tape number: 44

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	1	Ξ	Ω	1	1	1	∧	∧	...

↑
$q7$

Tape number: 45

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	1	Ξ	Ω	1	1	1	∧	∧	...

↑
$q8$

Tape number: 46

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	1	Ξ	Ω	1	1	1	∧	∧	...

↑
$q8$

Tape number: 47

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	$\wedge$	$\wedge$	1	M	Ψ	1	Ξ	Ω	1	1	1	$\wedge$	$\wedge$	...

$\uparrow$
$q8$

Tape number: 48

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	$\wedge$	$\wedge$	1	M	Ψ	1	Ξ	Ω	1	1	1	$\wedge$	$\wedge$	...

$\uparrow$
$q8$

Tape number: 49

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	$\wedge$	$\wedge$	1	M	Ψ	1	Ξ	Ω	1	1	1	1	$\wedge$	...

$\uparrow$
$q9$

Tape number: 50

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	$\wedge$	$\wedge$	1	M	Ψ	1	Ξ	Ω	1	1	1	1	$\wedge$	...

$\uparrow$
$q9$

Tape number: 51

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	$\wedge$	$\wedge$	1	M	Ψ	1	Ξ	Ω	1	1	1	1	$\wedge$	...

$\uparrow$
$q9$

Tape number: 52

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	$\wedge$	$\wedge$	1	M	Ψ	1	Ξ	Ω	1	1	1	1	$\wedge$	...

$\uparrow$
$q9$

Tape number: 53

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	1	Ξ	Ω	1	1	1	1	∧	...

↑
$q9$

Tape number: 54

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	1	1	Ω	1	1	1	1	∧	...

↑
$q12$

Tape number: 55

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	1	1	Ω	1	1	1	1	∧	...

↑
$q10$

Tape number: 56

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	1	1	Ω	1	1	1	1	∧	...

↑
$q10$

Tape number: 57

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	1	1	Ω	1	1	1	1	∧	...

↑
$q10$

Tape number: 58

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	M	Ψ	1	1	Ω	1	1	1	1	∧	...

↑
$q10$

Tape number: 59

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	1	Ψ	1	1	Ω	1	1	1	1	∧	...

↑
$q5$
Tape number: 60

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	1	Ψ	1	1	Ω	1	1	1	1	∧	...

↑
$q11$
Tape number: 61

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	1	Ψ	1	1	Ω	1	1	1	1	∧	...

↑
$q11$
Tape number: 62

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	1	Ψ	1	1	Ω	1	1	1	1	∧	...

↑
$q11$
Tape number: 63

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	
...	∧	∧	1	1	Ψ	1	1	Ω	1	1	1	1	∧	...

↑
$q14$
Tape number: 64

5.3 -1 x 5

Number of tapes: 111
Tape execution time: 4ms

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	$\wedge$	$\wedge$	Φ	1	Ψ	1	1	1	1	1	$\wedge$	$\wedge$	$\wedge$	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$
$q0$

Tape number: 0

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	$\wedge$	$\wedge$	Φ	1	Ψ	1	1	1	1	1	$\wedge$	$\wedge$	$\wedge$	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$
$q2$

Tape number: 1

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	$\wedge$	$\wedge$	Φ	1	Ψ	1	1	1	1	1	$\wedge$	$\wedge$	$\wedge$	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$
$q2$

Tape number: 2

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	$\wedge$	$\wedge$	Φ	1	Ψ	1	1	1	1	1	$\wedge$	$\wedge$	$\wedge$	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$
$q2$

Tape number: 3

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	$\wedge$	$\wedge$	Φ	1	Ψ	1	1	1	1	1	$\wedge$	$\wedge$	$\wedge$	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$
$q2$
Tape number: 4

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	$\wedge$	$\wedge$	Φ	1	Ψ	1	1	1	1	1	$\wedge$	$\wedge$	$\wedge$	$\wedge$	$\wedge$	$\wedge$	...

$\uparrow$
$q2$
Tape number: 5

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	1	Ψ	1	1	1	1	1	∧	∧	∧	∧	∧	∧	...

$\uparrow$

$q2$

Tape number: 6

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	1	Ψ	1	1	1	1	1	∧	∧	∧	∧	∧	∧	...

$\uparrow$

$q2$

Tape number: 7

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	1	Ψ	1	1	1	1	1	∧	∧	∧	∧	∧	∧	...

$\uparrow$

$q2$

Tape number: 8

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	∧	∧	∧	∧	∧	...

$\uparrow$

$q3$

Tape number: 9

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	Φ	∧	∧	∧	∧	...

$\uparrow$

$q4$

Tape number: 10

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	Φ	∧	∧	∧	∧	...

$\uparrow$

$q4$

Tape number: 11

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
... ∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	Φ	∧	∧	∧	∧ ...

↑
$q4$

Tape number: 12

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
... ∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	Φ	∧	∧	∧	∧ ...

↑
$q4$

Tape number: 13

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
... ∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	Φ	∧	∧	∧	∧ ...

↑
$q4$

Tape number: 14

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
... ∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	Φ	∧	∧	∧	∧ ...

↑
$q4$

Tape number: 15

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
... ∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	Φ	∧	∧	∧	∧ ...

↑
$q4$

Tape number: 16

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13
... ∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	Φ	∧	∧	∧	∧ ...

↑
$q4$

Tape number: 17

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	Φ	∧	∧	∧	∧	...

↑
$q4$

Tape number: 18

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	Φ	∧	∧	∧	∧	...

↑
$q4$

Tape number: 19

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	Φ	∧	∧	∧	∧	...

↑
$q5$

Tape number: 20

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	Φ	∧	∧	∧	∧	...

↑
$q5$

Tape number: 21

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	1	1	1	1	Ω	Φ	∧	∧	∧	∧	...

↑
$q6$

Tape number: 22

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	1	1	1	1	Ω	Φ	∧	∧	∧	∧	...

↑
$q12$

Tape number: 23

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	Ξ	1	1	1	1	Ω	Φ	∧	∧	∧	∧	...

$\uparrow$

$q7$

Tape number: 24

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	Ξ	1	1	1	1	Ω	Φ	∧	∧	∧	∧	...

$\uparrow$

$q7$

Tape number: 25

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	Ξ	1	1	1	1	Ω	Φ	∧	∧	∧	∧	...

$\uparrow$

$q7$

Tape number: 26

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	Ξ	1	1	1	1	Ω	Φ	∧	∧	∧	∧	...

$\uparrow$

$q7$

Tape number: 27

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	Ξ	1	1	1	1	Ω	Φ	∧	∧	∧	∧	...

$\uparrow$

$q7$

Tape number: 28

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	Ξ	1	1	1	1	Ω	Φ	∧	∧	∧	∧	...

$\uparrow$

$q8$

Tape number: 29

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	Ξ	1	1	1	1	Ω	Φ	∧	∧	∧	∧	...

$$\uparrow$$
$$q8$$

Tape number: 30

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	Ξ	1	1	1	1	Ω	Φ	1	∧	∧	∧	...

$$\uparrow$$
$$q9$$

Tape number: 31

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	Ξ	1	1	1	1	Ω	Φ	1	∧	∧	∧	...

$$\uparrow$$
$$q9$$

Tape number: 32

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	Ξ	1	1	1	1	Ω	Φ	1	∧	∧	∧	...

$$\uparrow$$
$$q9$$

Tape number: 33

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	Ξ	1	1	1	1	Ω	Φ	1	∧	∧	∧	...

$$\uparrow$$
$$q9$$

Tape number: 34

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	Ξ	1	1	1	1	Ω	Φ	1	∧	∧	∧	...

$$\uparrow$$
$$q9$$

Tape number: 35

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	Ξ	1	1	1	1	Ω	Φ	1	∧	∧	∧	...

↑
$q9$

Tape number: 36

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	Ξ	1	1	1	1	Ω	Φ	1	∧	∧	∧	...

↑
$q9$

Tape number: 37

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	1	1	1	1	Ω	Φ	1	∧	∧	∧	...

↑
$q12$

Tape number: 38

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	Ξ	1	1	1	Ω	Φ	1	∧	∧	∧	...

↑
$q7$

Tape number: 39

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	Ξ	1	1	1	Ω	Φ	1	∧	∧	∧	...

↑
$q7$

Tape number: 40

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	Ξ	1	1	1	Ω	Φ	1	∧	∧	∧	...

↑
$q7$

Tape number: 41

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	Ξ	1	1	1	Ω	Φ	1	∧	∧	∧	...

$$\uparrow$$
$$q7$$

Tape number: 42

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	Ξ	1	1	1	Ω	Φ	1	∧	∧	∧	...

$$\uparrow$$
$$q8$$

Tape number: 43

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	Ξ	1	1	1	Ω	Φ	1	∧	∧	∧	...

$$\uparrow$$
$$q8$$

Tape number: 44

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	Ξ	1	1	1	Ω	Φ	1	∧	∧	∧	...

$$\uparrow$$
$$q8$$

Tape number: 45

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	Ξ	1	1	1	Ω	Φ	1	1	∧	∧	...

$$\uparrow$$
$$q9$$

Tape number: 46

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	Ξ	1	1	1	Ω	Φ	1	1	∧	∧	...

$$\uparrow$$
$$q9$$

Tape number: 47

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	Ξ	1	1	1	Ω	Φ	1	1	∧	∧	...

↑
$q9$
Tape number: 48

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	Ξ	1	1	1	Ω	Φ	1	1	∧	∧	...

↑
$q9$
Tape number: 49

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	Ξ	1	1	1	Ω	Φ	1	1	∧	∧	...

↑
$q9$
Tape number: 50

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	Ξ	1	1	1	Ω	Φ	1	1	∧	∧	...

↑
$q9$
Tape number: 51

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	Ξ	1	1	1	Ω	Φ	1	1	∧	∧	...

↑
$q9$
Tape number: 52

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	1	1	1	1	Ω	Φ	1	1	∧	∧	...

↑
$q12$
Tape number: 53

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	Ξ	1	1	Ω	Φ	1	1	$\wedge$	$\wedge$	...

$$\uparrow$$
$$q7$$

Tape number: 54

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	Ξ	1	1	Ω	Φ	1	1	$\wedge$	$\wedge$	...

$$\uparrow$$
$$q7$$

Tape number: 55

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	Ξ	1	1	Ω	Φ	1	1	$\wedge$	$\wedge$	...

$$\uparrow$$
$$q7$$

Tape number: 56

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	Ξ	1	1	Ω	Φ	1	1	$\wedge$	$\wedge$	...

$$\uparrow$$
$$q8$$

Tape number: 57

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	Ξ	1	1	Ω	Φ	1	1	$\wedge$	$\wedge$	...

$$\uparrow$$
$$q8$$

Tape number: 58

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	Ξ	1	1	Ω	Φ	1	1	$\wedge$	$\wedge$	...

$$\uparrow$$
$$q8$$

Tape number: 59

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	1	Ξ	1	1	Ω	Φ	1	1	∧	∧	...

$\uparrow$
$q8$

Tape number: 60

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	1	Ξ	1	1	Ω	Φ	1	1	1	∧	...

$\uparrow$
$q9$

Tape number: 61

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	1	Ξ	1	1	Ω	Φ	1	1	1	∧	...

$\uparrow$
$q9$

Tape number: 62

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	1	Ξ	1	1	Ω	Φ	1	1	1	∧	...

$\uparrow$
$q9$

Tape number: 63

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	1	Ξ	1	1	Ω	Φ	1	1	1	∧	...

$\uparrow$
$q9$

Tape number: 64

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	1	Ξ	1	1	Ω	Φ	1	1	1	∧	...

$\uparrow$
$q9$

Tape number: 65

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	1	Ξ	1	1	Ω	Φ	1	1	1	∧	...

$\uparrow$

$q9$

Tape number: 66

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	1	Ξ	1	1	Ω	Φ	1	1	1	∧	...

$\uparrow$

$q9$

Tape number: 67

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	1	1	1	1	Ω	Φ	1	1	1	∧	...

$\uparrow$

$q12$

Tape number: 68

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	1	1	Ξ	1	Ω	Φ	1	1	1	∧	...

$\uparrow$

$q7$

Tape number: 69

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	1	1	Ξ	1	Ω	Φ	1	1	1	∧	...

$\uparrow$

$q7$

Tape number: 70

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	∧	∧	Φ	M	Ψ	1	1	1	Ξ	1	Ω	Φ	1	1	1	∧	...

$\uparrow$

$q8$

Tape number: 71

27

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	1	Ξ	1	Ω	Φ	1	1	1	$\wedge$	...

$$\uparrow$$
$$q8$$

Tape number: 72

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	1	Ξ	1	Ω	Φ	1	1	1	$\wedge$	...

$$\uparrow$$
$$q8$$

Tape number: 73

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	1	Ξ	1	Ω	Φ	1	1	1	$\wedge$	...

$$\uparrow$$
$$q8$$

Tape number: 74

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	1	Ξ	1	Ω	Φ	1	1	1	$\wedge$	...

$$\uparrow$$
$$q8$$

Tape number: 75

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	1	Ξ	1	Ω	Φ	1	1	1	1	$\wedge$	$\wedge$	...

$$\uparrow$$
$$q9$$

Tape number: 76

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	1	Ξ	1	Ω	Φ	1	1	1	1	$\wedge$	$\wedge$	...

$$\uparrow$$
$$q9$$

Tape number: 77

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	∧	∧	Φ	M	Ψ	1	1	1	Ξ	1	Ω	Φ	1	1	1	1	∧	∧	...

$\uparrow$
$q9$

Tape number: 78

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	∧	∧	Φ	M	Ψ	1	1	1	Ξ	1	Ω	Φ	1	1	1	1	∧	∧	...

$\uparrow$
$q9$

Tape number: 79

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	∧	∧	Φ	M	Ψ	1	1	1	Ξ	1	Ω	Φ	1	1	1	1	∧	∧	...

$\uparrow$
$q9$

Tape number: 80

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	∧	∧	Φ	M	Ψ	1	1	1	Ξ	1	Ω	Φ	1	1	1	1	∧	∧	...

$\uparrow$
$q9$

Tape number: 81

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	∧	∧	Φ	M	Ψ	1	1	1	Ξ	1	Ω	Φ	1	1	1	1	∧	∧	...

$\uparrow$
$q9$

Tape number: 82

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	∧	∧	Φ	M	Ψ	1	1	1	1	1	Ω	Φ	1	1	1	1	∧	∧	...

$\uparrow$
$q12$

Tape number: 83

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	1	1	Ξ	Ω	Φ	1	1	1	1	$\wedge$	$\wedge$	...

$\uparrow$
$q7$

Tape number: 84

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	1	1	Ξ	Ω	Φ	1	1	1	1	$\wedge$	$\wedge$	...

$\uparrow$
$q8$

Tape number: 85

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	1	1	Ξ	Ω	Φ	1	1	1	1	$\wedge$	$\wedge$	...

$\uparrow$
$q8$

Tape number: 86

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	1	1	Ξ	Ω	Φ	1	1	1	1	$\wedge$	$\wedge$	...

$\uparrow$
$q8$

Tape number: 87

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	1	1	Ξ	Ω	Φ	1	1	1	1	$\wedge$	$\wedge$	...

$\uparrow$
$q8$

Tape number: 88

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	$\wedge$	$\wedge$	Φ	M	Ψ	1	1	1	1	Ξ	Ω	Φ	1	1	1	1	$\wedge$	$\wedge$	...

$\uparrow$
$q8$

Tape number: 89

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
...	∧	∧	Φ	M	Ψ	1	1	1	1	Ξ	Ω	Φ	1	1	1	1	∧	∧	...

↑
$q8$ (at column 14)

Tape number: 90

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
...	∧	∧	Φ	M	Ψ	1	1	1	1	Ξ	Ω	Φ	1	1	1	1	1	∧	...

↑
$q9$ (at column 13)

Tape number: 91

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
...	∧	∧	Φ	M	Ψ	1	1	1	1	Ξ	Ω	Φ	1	1	1	1	1	∧	...

↑
$q9$ (at column 12)

Tape number: 92

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
...	∧	∧	Φ	M	Ψ	1	1	1	1	Ξ	Ω	Φ	1	1	1	1	1	∧	...

↑
$q9$ (at column 11)

Tape number: 93

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
...	∧	∧	Φ	M	Ψ	1	1	1	1	Ξ	Ω	Φ	1	1	1	1	1	∧	...

↑
$q9$ (at column 10)

Tape number: 94

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
...	∧	∧	Φ	M	Ψ	1	1	1	1	Ξ	Ω	Φ	1	1	1	1	1	∧	...

↑
$q9$ (at column 9)

Tape number: 95

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	∧	∧	Φ	M	Ψ	1	1	1	1	Ξ	Ω	Φ	1	1	1	1	1	∧	...

↑
$q9$
Tape number: 96

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	∧	∧	Φ	M	Ψ	1	1	1	1	Ξ	Ω	Φ	1	1	1	1	1	∧	...

↑
$q9$
Tape number: 97

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	∧	∧	Φ	M	Ψ	1	1	1	1	1	Ω	Φ	1	1	1	1	1	∧	...

↑
$q12$
Tape number: 98

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	∧	∧	Φ	M	Ψ	1	1	1	1	1	Ω	Φ	1	1	1	1	1	∧	...

↑
$q10$
Tape number: 99

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	∧	∧	Φ	M	Ψ	1	1	1	1	1	Ω	Φ	1	1	1	1	1	∧	...

↑
$q10$
Tape number: 100

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	∧	∧	Φ	M	Ψ	1	1	1	1	1	Ω	Φ	1	1	1	1	1	∧	...

↑
$q10$
Tape number: 101

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
...	∧	∧	Φ	M	Ψ	1	1	1	1	1	Ω	Φ	1	1	1	1	1	∧	...

↑
$q10$

Tape number: 102

....

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
...	∧	∧	Φ	M	Ψ	1	1	1	1	1	Ω	Φ	1	1	1	1	1	∧	...

↑
$q10$

Tape number: 103

....

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
...	∧	∧	Φ	M	Ψ	1	1	1	1	1	Ω	Φ	1	1	1	1	1	∧	...

↑
$q10$

Tape number: 104

....

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
...	∧	∧	Φ	M	Ψ	1	1	1	1	1	Ω	Φ	1	1	1	1	1	∧	...

↑
$q10$

Tape number: 105

....

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
...	∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	Φ	1	1	1	1	1	∧	...

↑
$q5$

Tape number: 106

....

-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
...	∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	Φ	1	1	1	1	1	∧	...

↑
$q11$

Tape number: 107

....

33

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	Φ	1	1	1	1	1	∧	...

↑
$q11$

Tape number: 108

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	Φ	1	1	1	1	1	∧	...

↑
$q11$

Tape number: 109

	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
...	∧	∧	Φ	1	Ψ	1	1	1	1	1	Ω	Φ	1	1	1	1	1	∧	...

↑
$q14$

Tape number: 110

6 Efficiency of program

comment on the number of computation sequences produced and the time taked to complete each test

7 Power of 3 machine

asd