Figured Magic Squares of Order 22 Using Bordered Magic Rectangles: A Systematic Procedure

Inder J. Taneja[1]

Abstract

Recently, author constructed even order magic squares from orders 6 to 20 with different styles and models, for examples the order 20 is with 1616 magic squares, order 18 with 810 magic squares, etc. These can be seen at [31, 32, 33, 33, 34, 35, 36, 37]. The aim is to proceed for the further orders of magic squares. In this work there are few examples of magic squares given as figures of order 20. A systematic procedure to construct these magic squares is given. It is based on the magic squares and bordered magic rectangles (BMR) of orders 4, 6, 8 etc forming external borders. Then the internal borders are filled with previous known magic squares. The presentations is in figures instead of numbers. The readers can find replies in numbers from references given above. For the orders multiples of 4, we can always write magic squares with equal sums blocks of magic squares of order 4. This procedure is very helpful for the orders of type ***2p****, where* ***p*** *is a prime number, for examples, 14, 22, 26, 34, 38, etc. For the orders like 18, 30, etc. we can make good external blocks with order 4, and for orders like 16, 20, 28, 32, etc. we can make good external borders of order 6, and so on.*

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Contents

1 Introduction

The magic sums of order n of consecutive numbers from 1 to n^2 is given by

$$S_{n\times n} := \frac{n\times(1+n^2)}{2}, n \geq 3. \tag{1}$$

Recently, the author [31, 32, 33, 34, 35, 36, 37] constructed magic squares of even orders from 8 to 20 using **bordered magic rectangles**. This construction is based on two aspects:

(i) Using **magic rectangles** or **bordered magic rectangles**.

(ii) Using algebraic formula like $(\mathbf{a}+\mathbf{b})^2, \mathbf{a}\neq\mathbf{b}$.

For the above magic squares no construction procedure is explained. The aim is to proceed further orders of magic squares. In this work, a systematic procedure to construct these magic squares is given. It is based on the magic squares and bordered magic rectangles (BMR) of orders 4, 6, 8 etc forming external borders. Then the internal borders are filled with previous known magic squares. For the orders multiples of 4, we can always write magic squares with equal sums blocks of magic squares of order 4. This procedure is very helpful for the orders of type **2p**, where **p** is a prime number, for examples, 14, 22, 26, 34, 38, etc. For the orders like 18, 30, etc.,we can make good external blocks with order 4, and for orders like 16, 20, 28, 32, etc. we can make good external borders of order 6, and so on. There is no explainations for the orders 6, 8, 10 and 12. The real construction starts from the order 14.

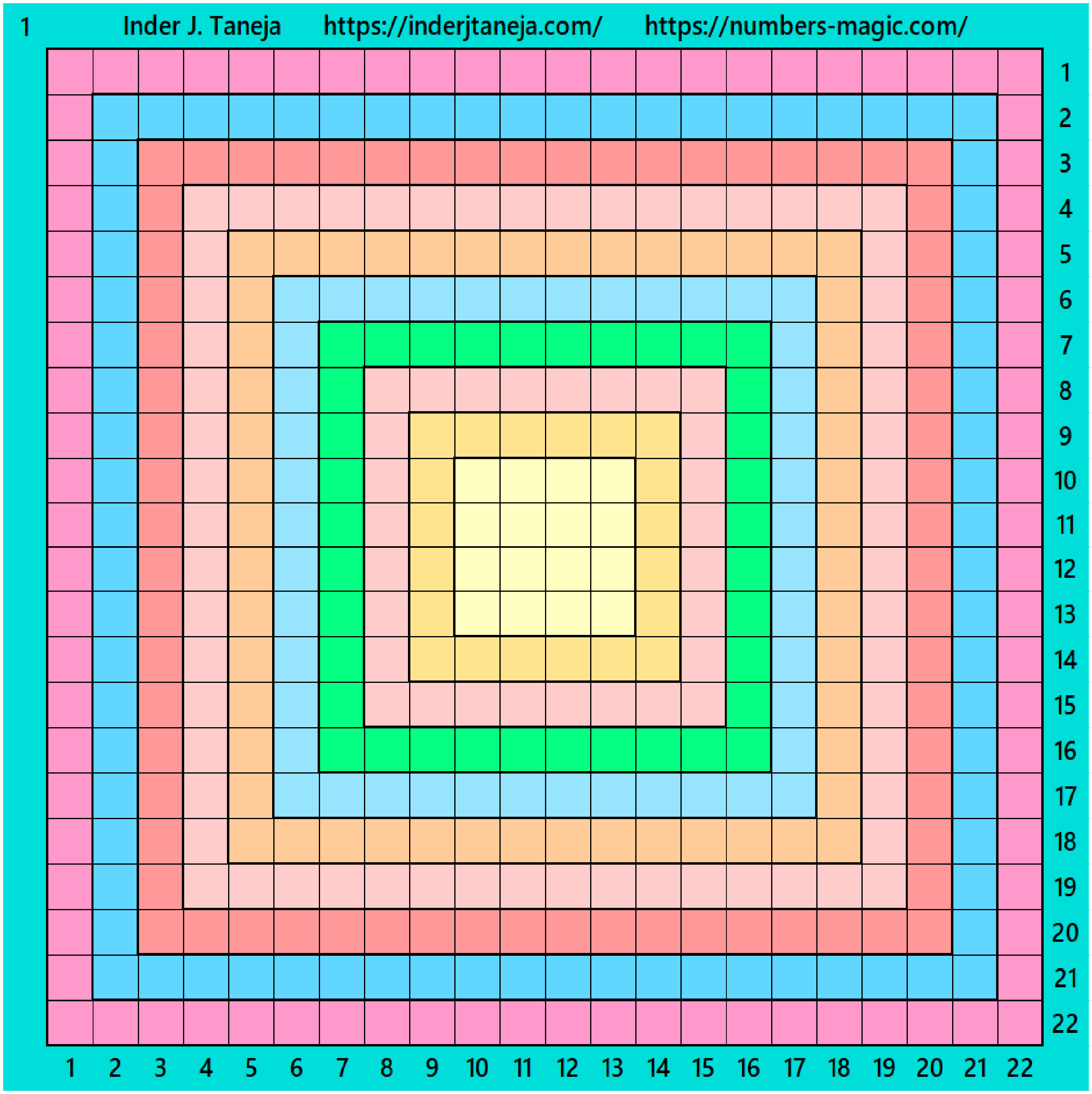
The whole the work is done manually, without use of any programming language, except for the constructions of small blocks of **bordered magic rectangles**. This construction is based on the software due to H. While. Later, these BRM's are readopted according to distribution of each magic square. The distribution of magic squares or bordered magic rectangles is based on **half-sequential** numbers. By **half-sequential** numbers we understand that the total numbers in each case are divided in two equal parts. First part is one sequence and second part is another sequence. Due to **half-sequential** numbers, it is not possible to construct all orders **bordered magic rectangles**. In Appendix 3, there are tables showing the existence of these **bordered magic rectangles** for **half-sequential**. For simplicity, we shall write **BMR** as **bordered magic rectangle**.

2 Magic Squares of Order 22

This section brings in figures (without numbers) magic squares of order 22. In some case its construction is explained.

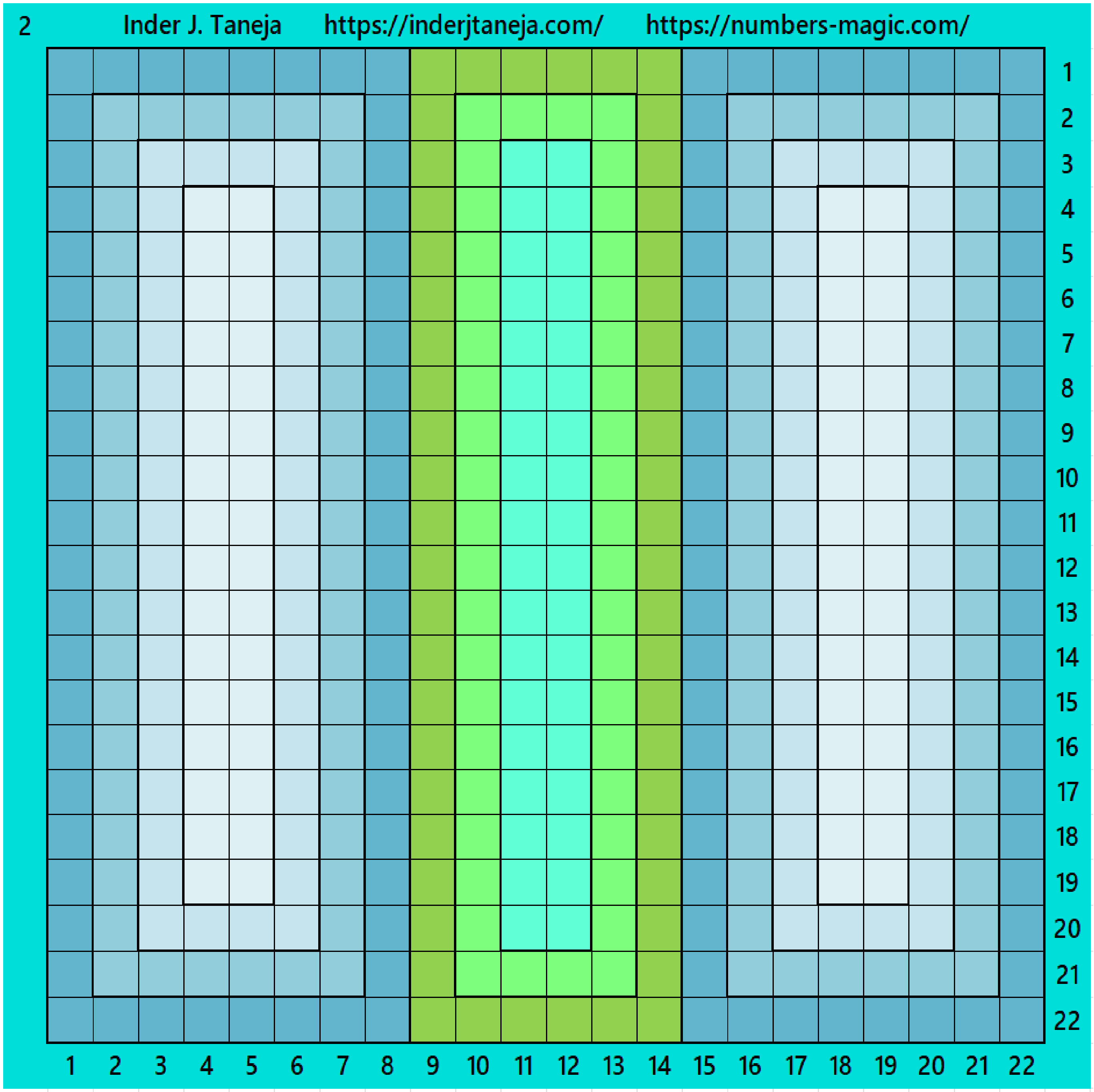
2.1 Bordered Square of Order 22

Below are four magic squares of order 22 already known in the literature. For more details refer author's work [22, 24].



2.2 Magic Squares of Order 20 With BMR

Below are three examples of magic squares of order 22 made with BMR. These are constructed separately. For more details with numbers refer [37].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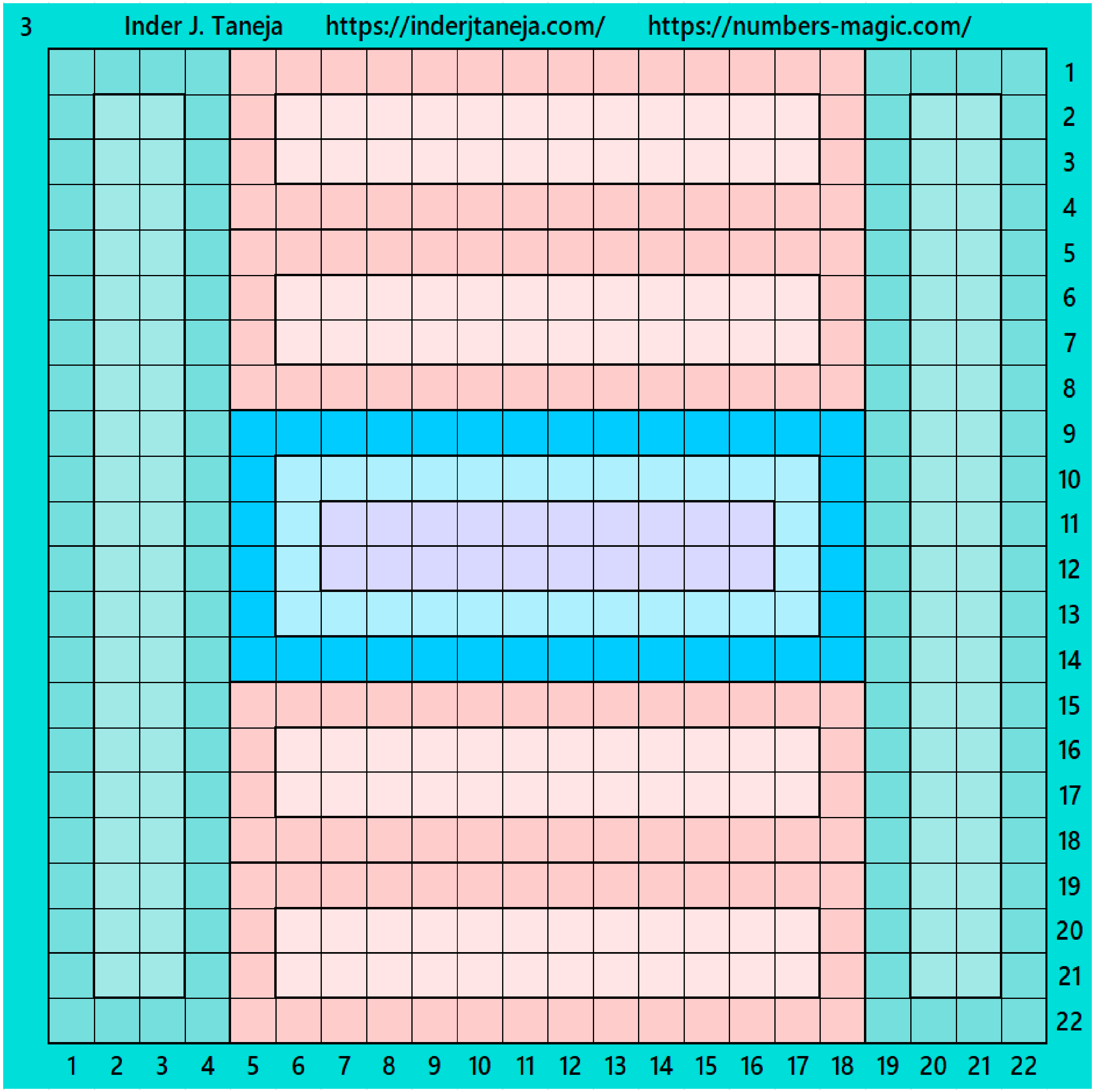
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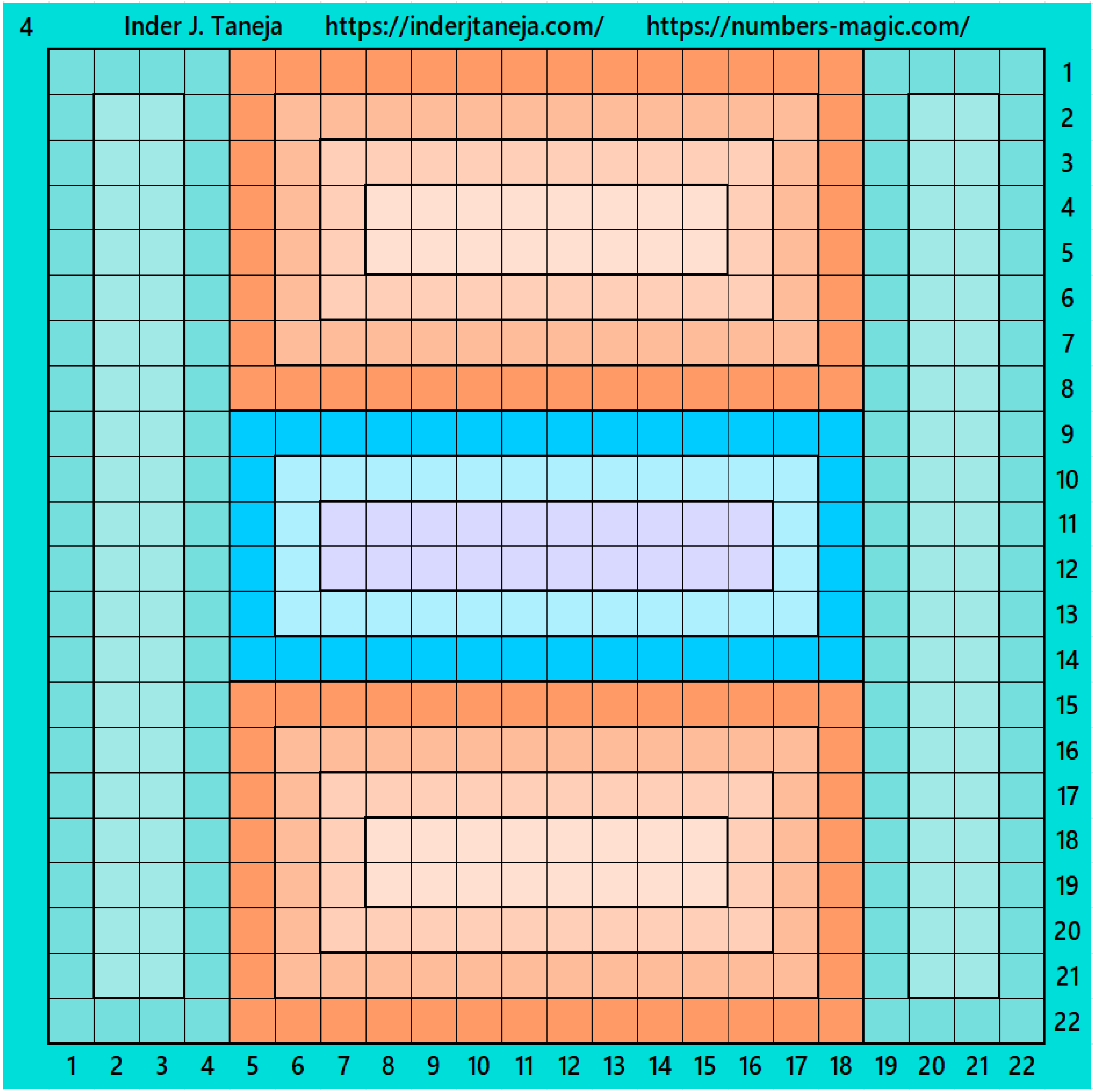
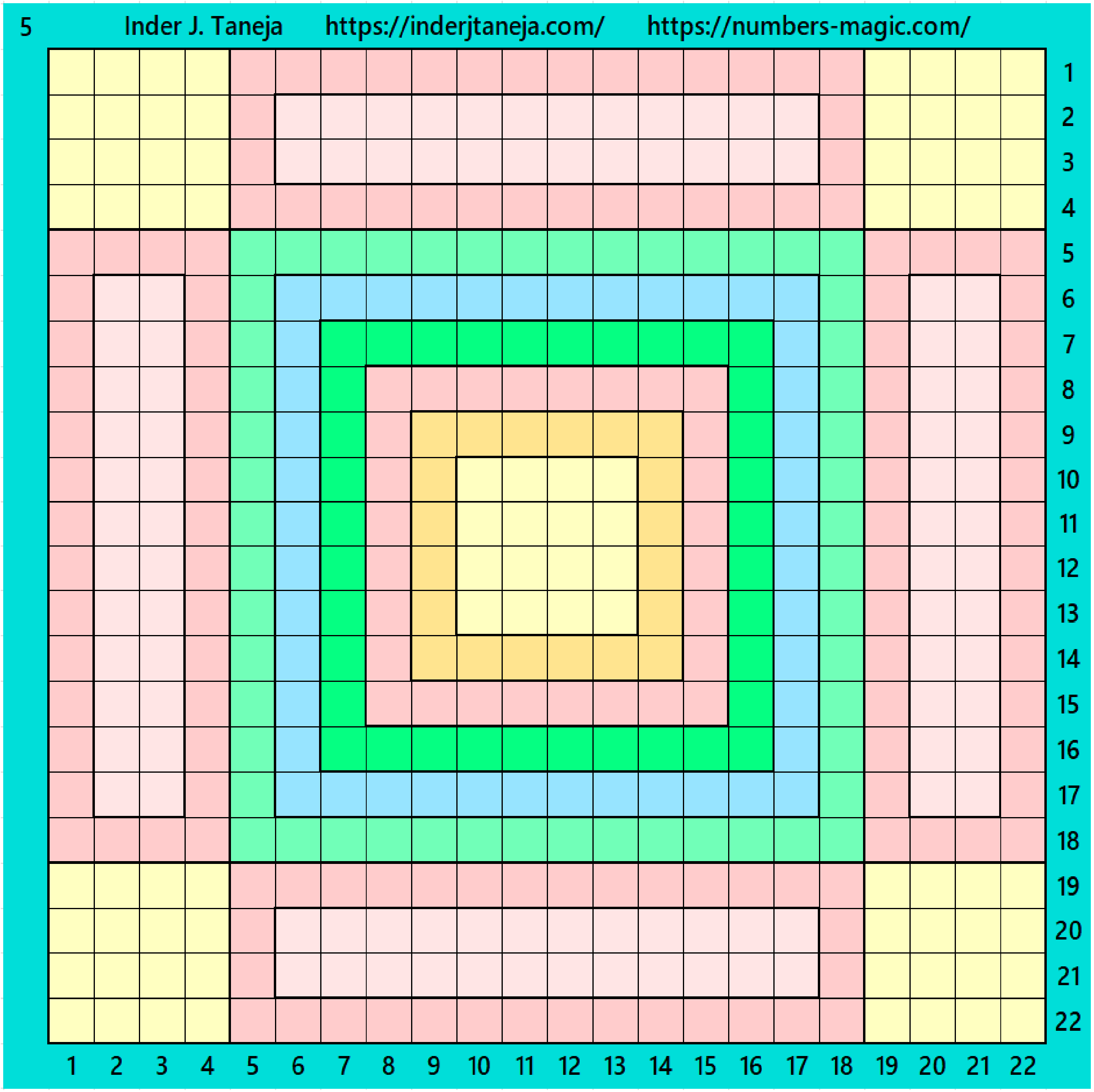
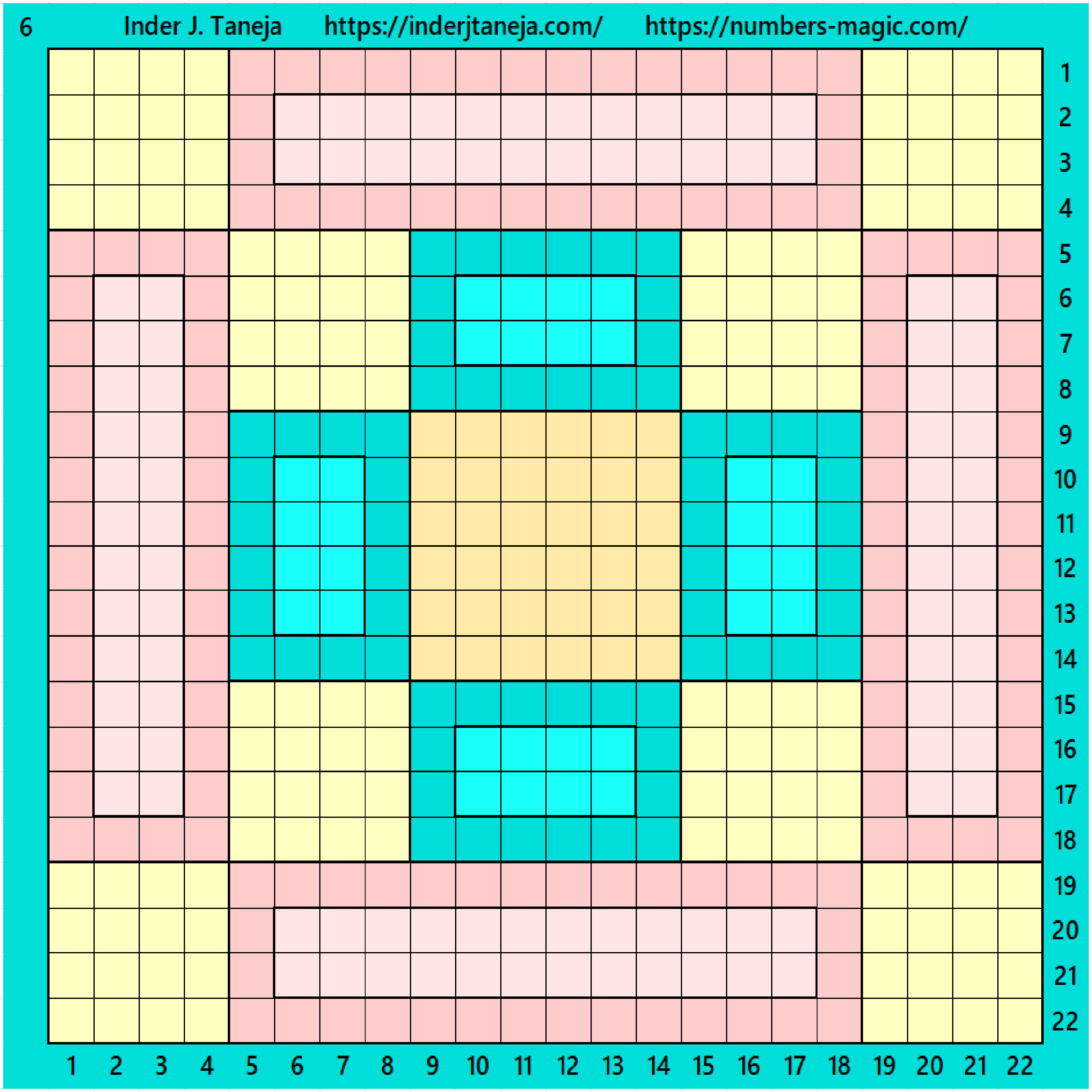


2.3 Cornered Magic Squares of Order 4

Let's consider an external border, where there are 4 magic squares of order 4 at the corners. Let's make an external border by putting BMR of order 4×14 in each row and column. In the

middle we are left with block of order 14. Writing middle block of order 14 with different types of magic squares, we get magic squares of order 22. See below few examples:

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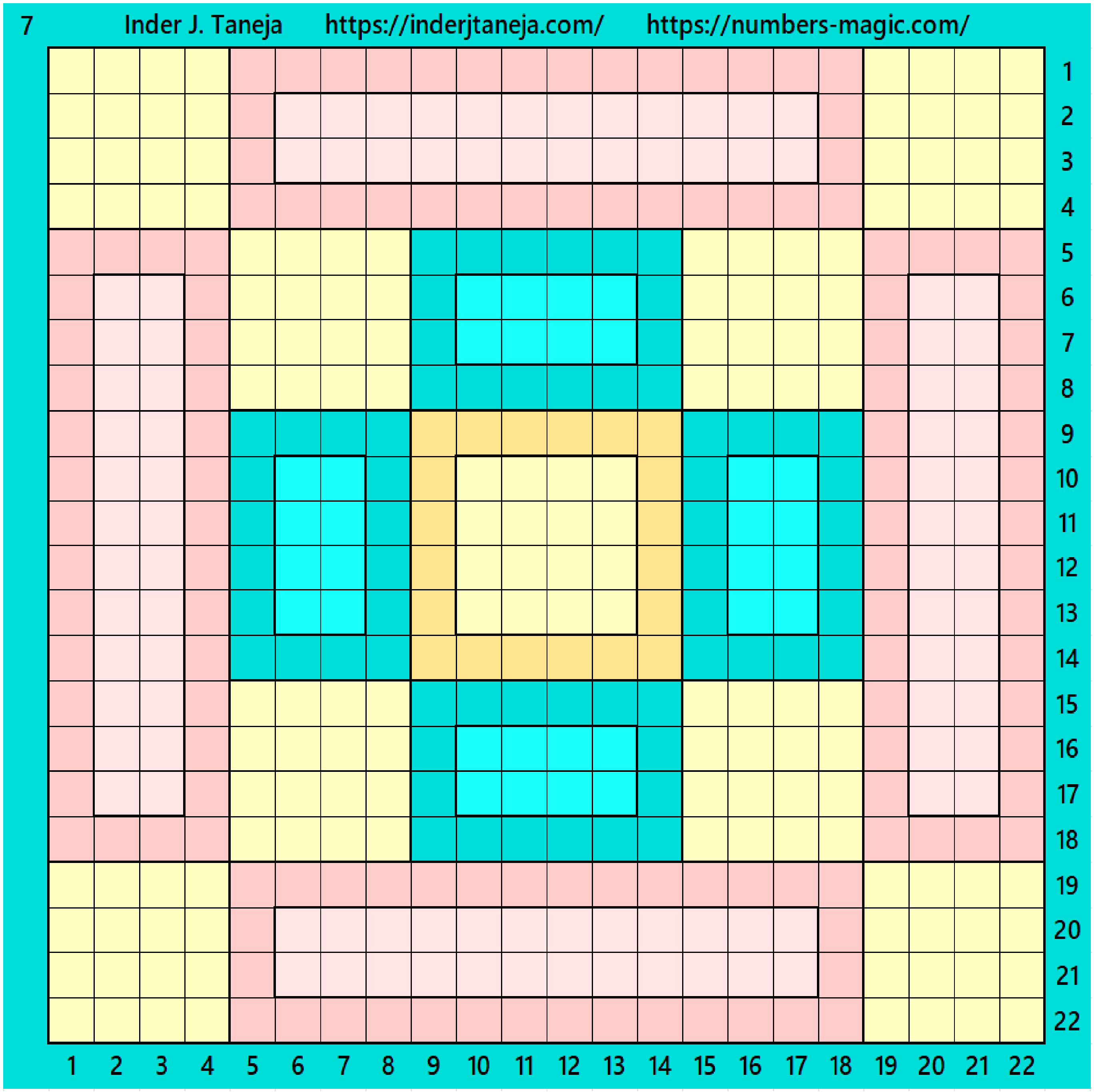
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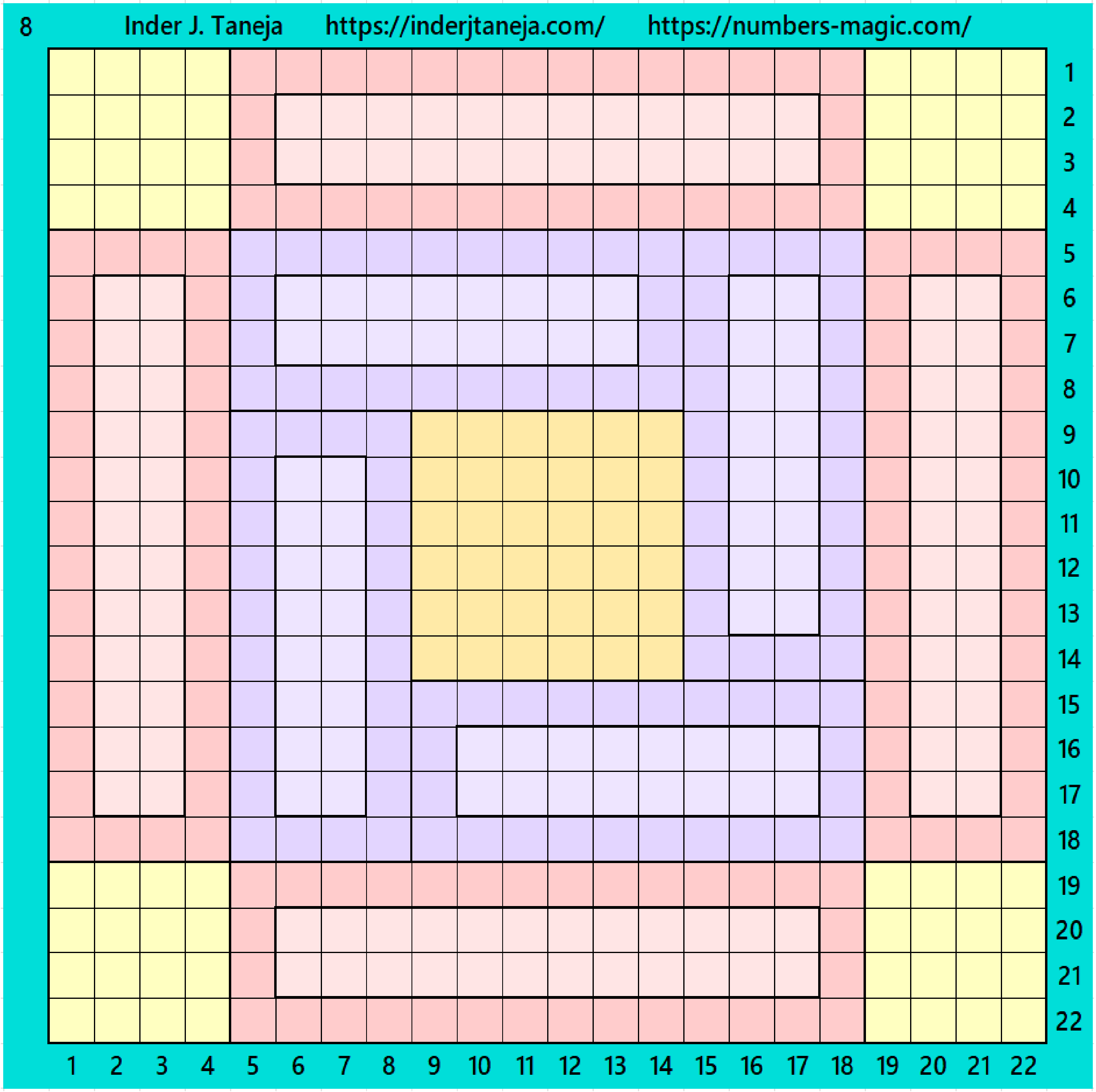
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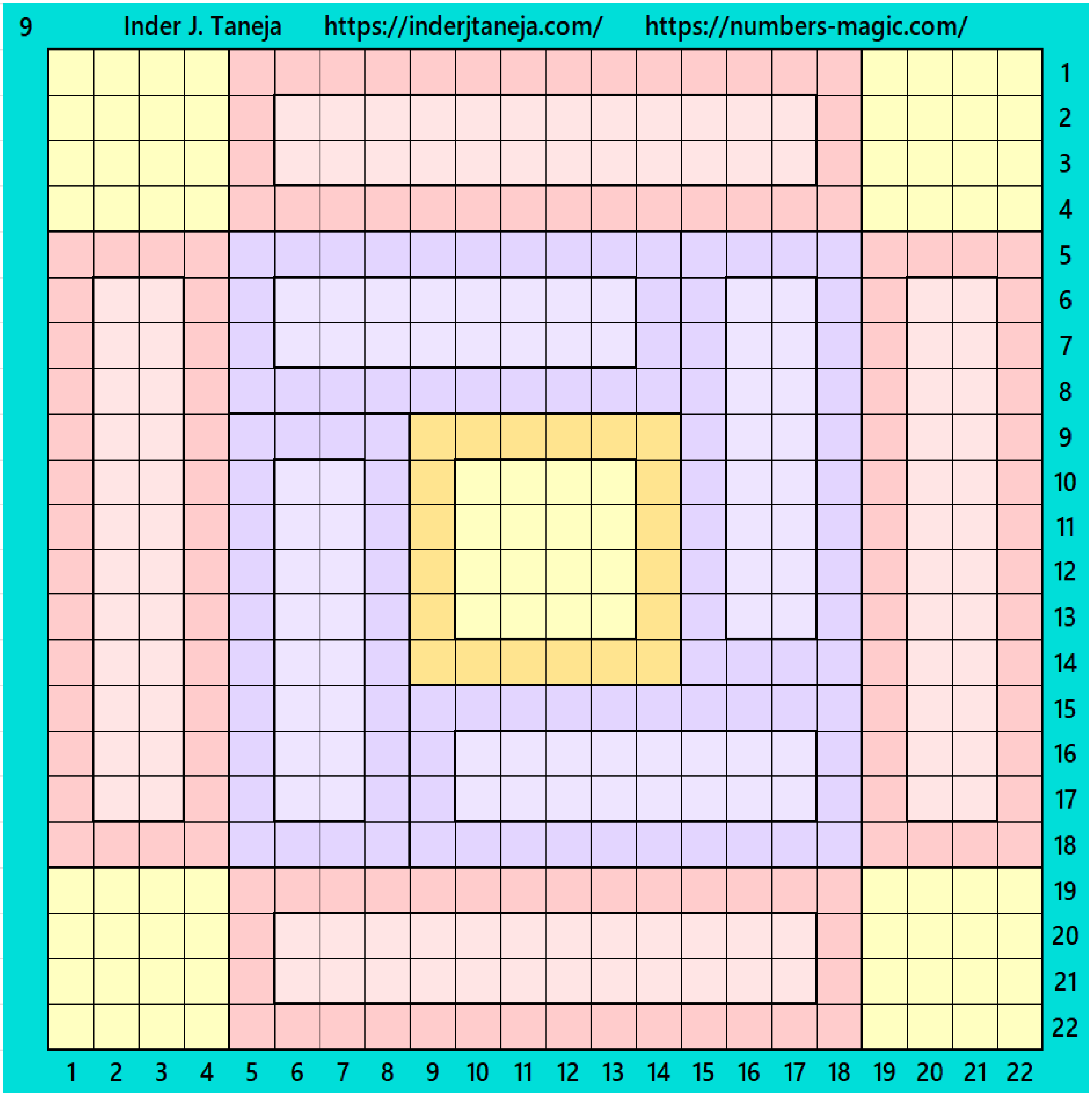
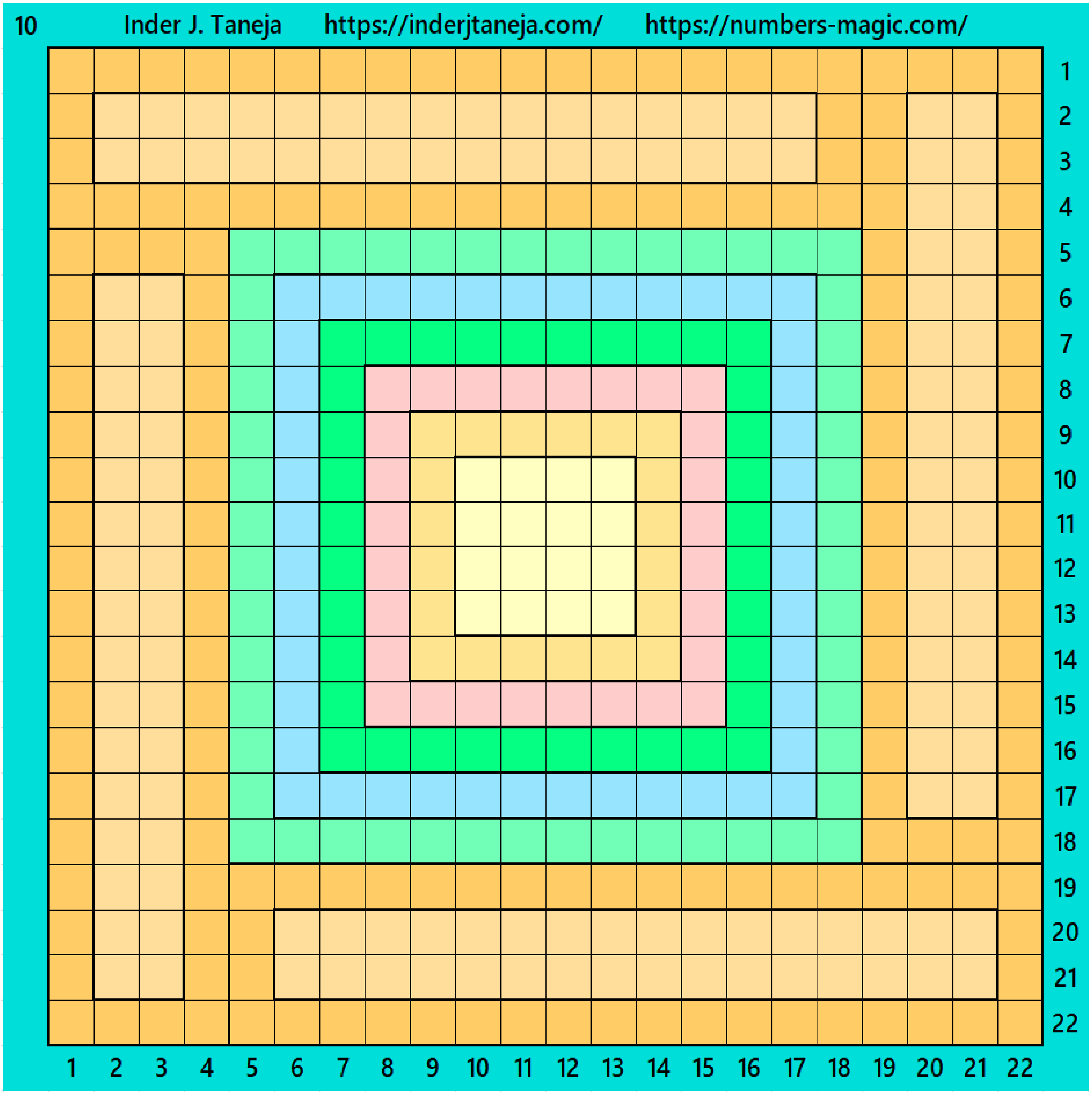
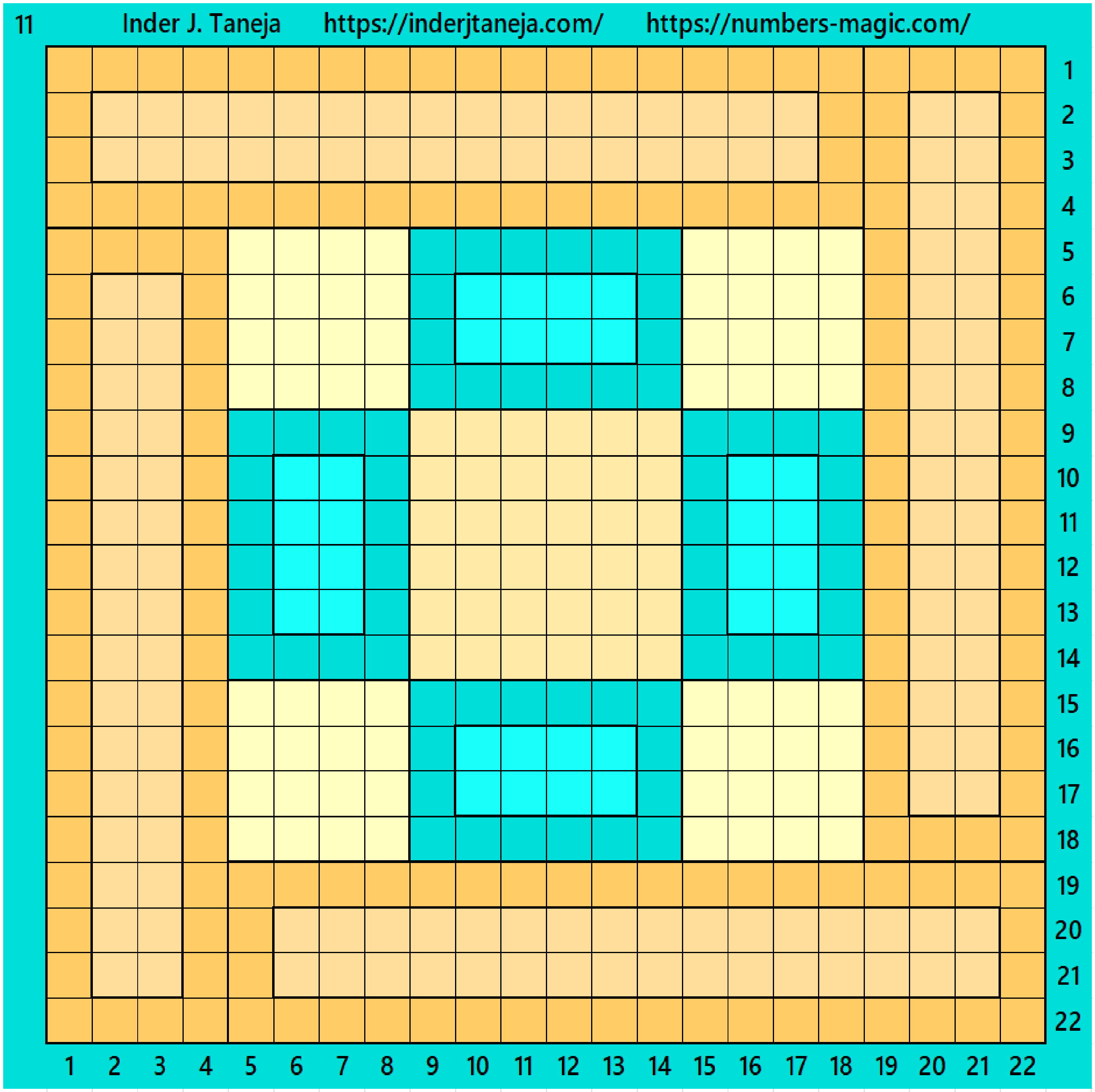


2.4 Closed Border of Order 4

Let's consider 4 equal sums BMR of order 4×14. Then put them in a symmetric way in external part of the magic squares. We are left with internal block of order 14. Writing middle block of order 14 with different types of magic squares of order 14, we get magic squares of order 22. See below few examples:

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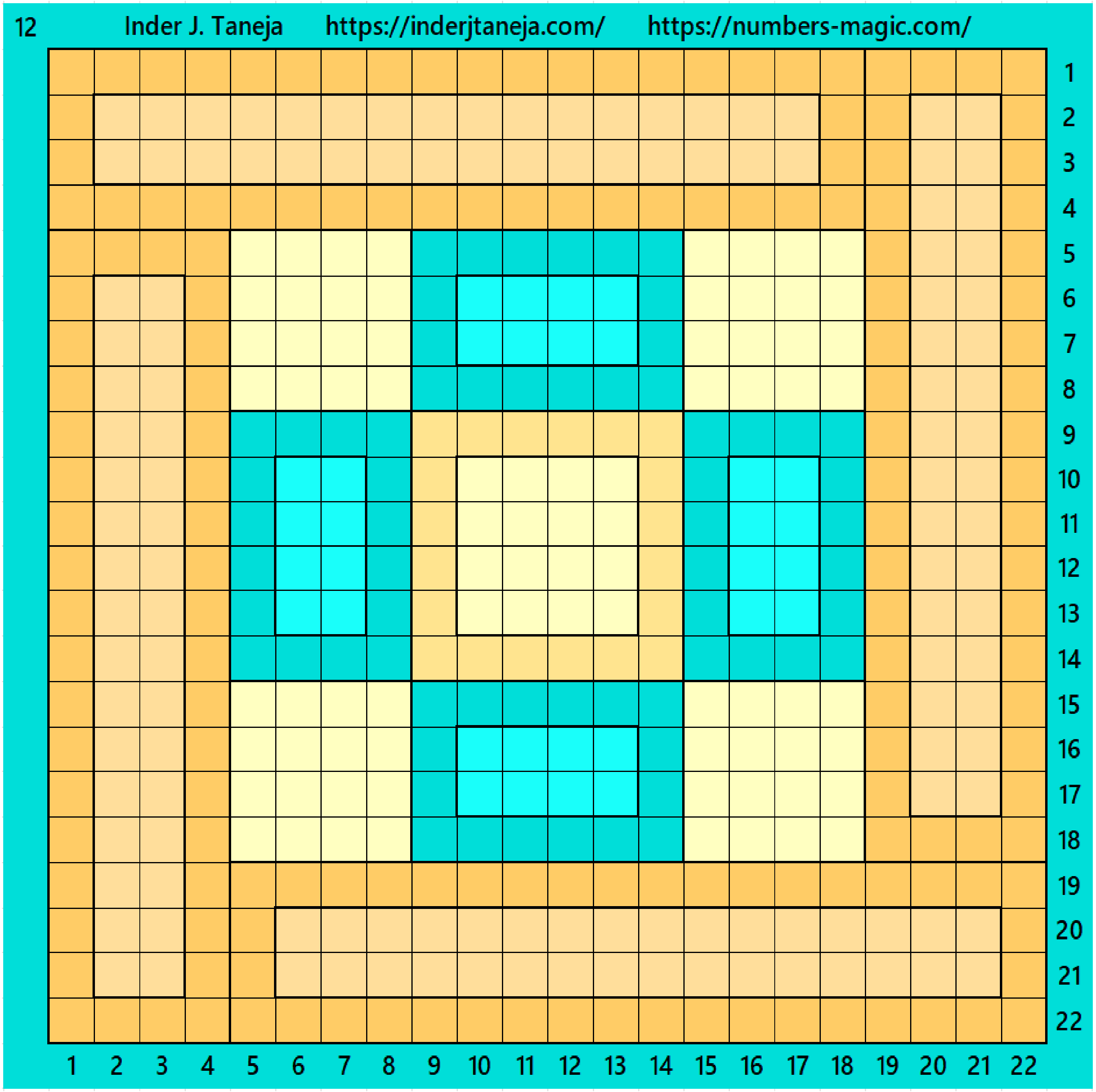
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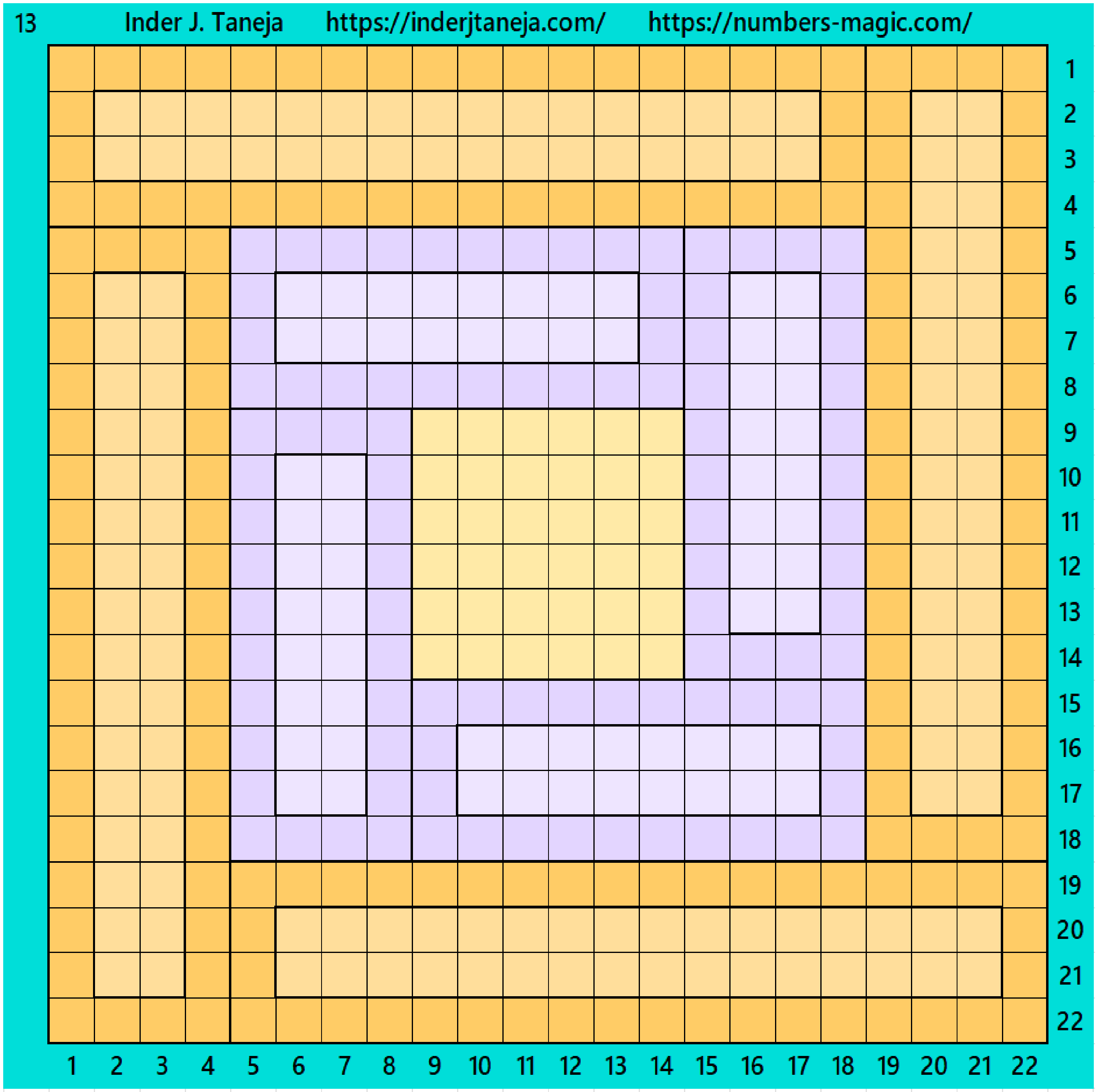
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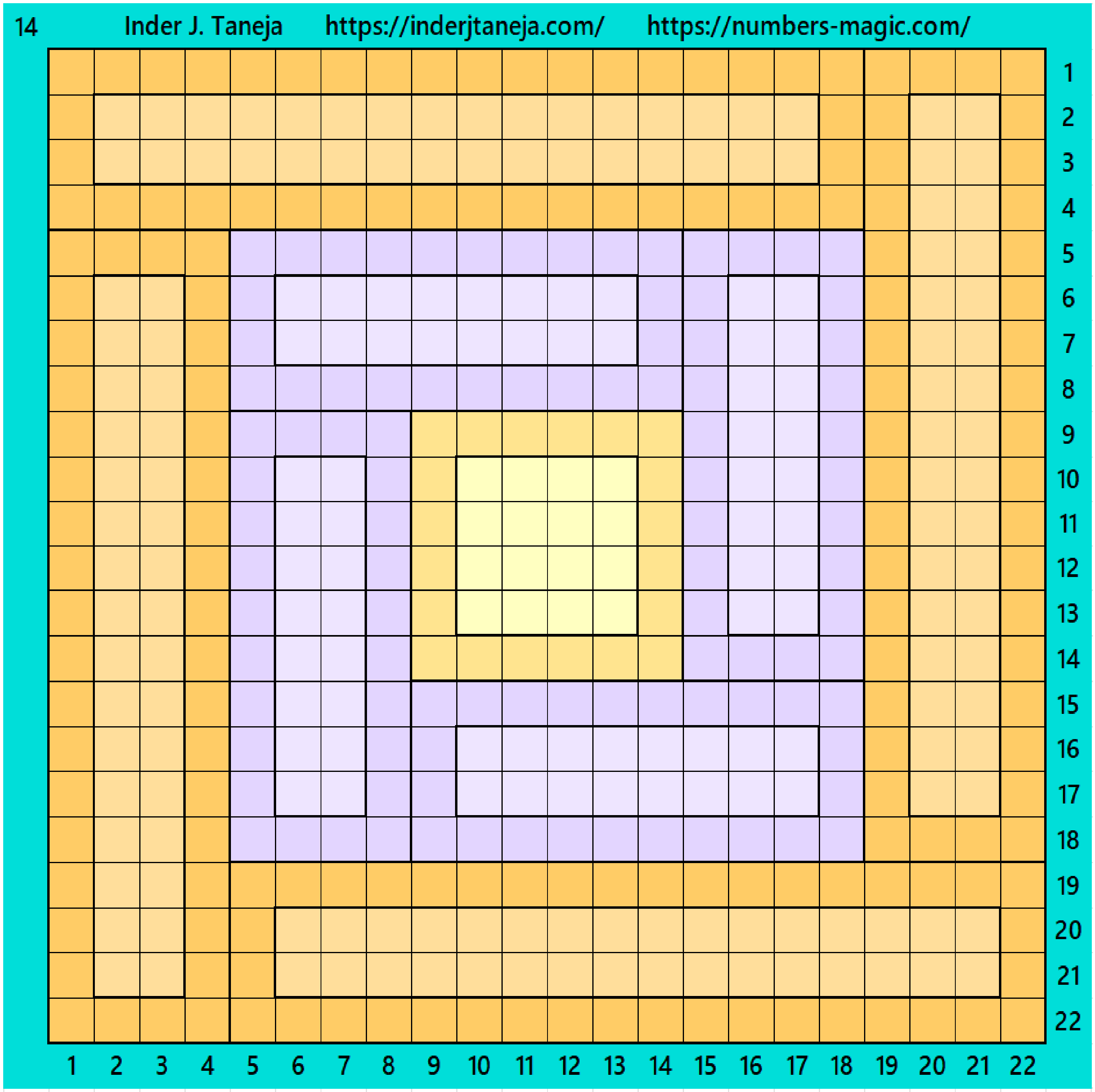
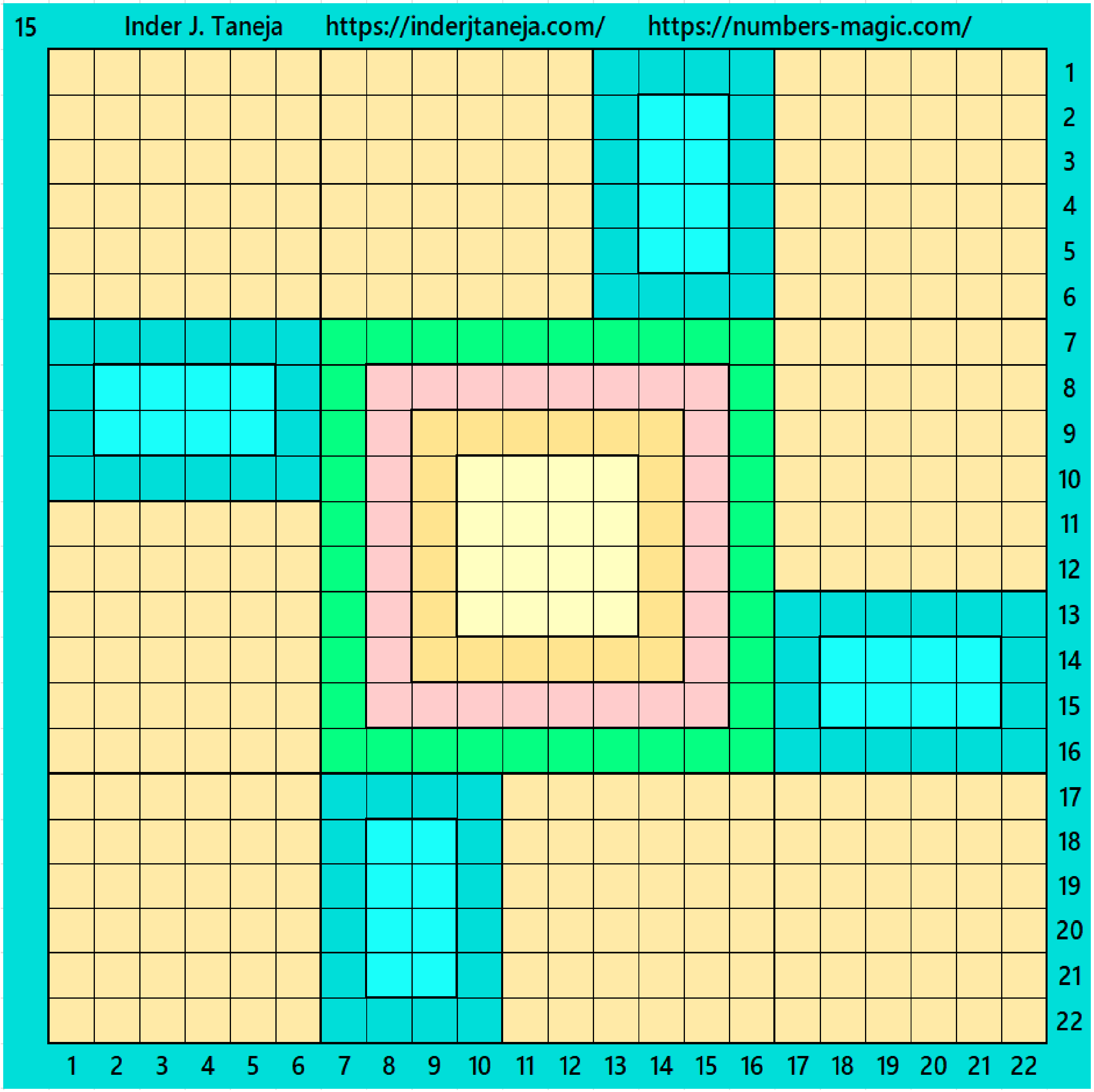


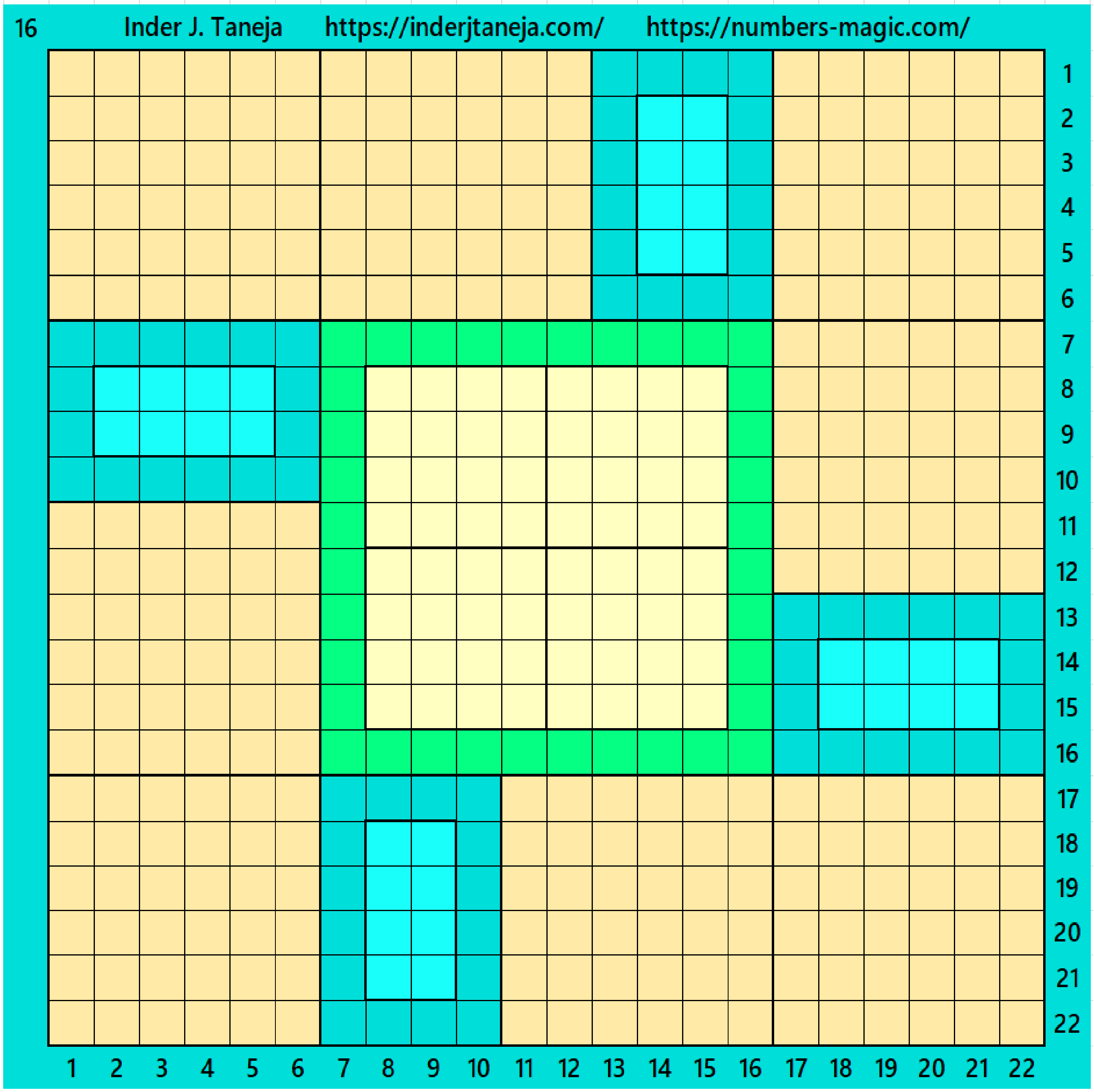
2.5 Cornered Magic Squares of Order 6

Let's consider an external border, where there are 8 magic squares of order 6 at the corners. Let's make an external border by putting BMR of order 4×6 in each row and column. In the

Figured Magic Squares of Order 22 Using Bordered Magic Rectangles: A Systematic Procedure, **Zenodo**, November 14, 2022, pp. 1-26, https://doi.org/10.5281/zenodo.7377706

middle we are left with block of order 10. Writing middle block of order 10 with different types of magic squares, we get magic squares of order 22. See below few examples:

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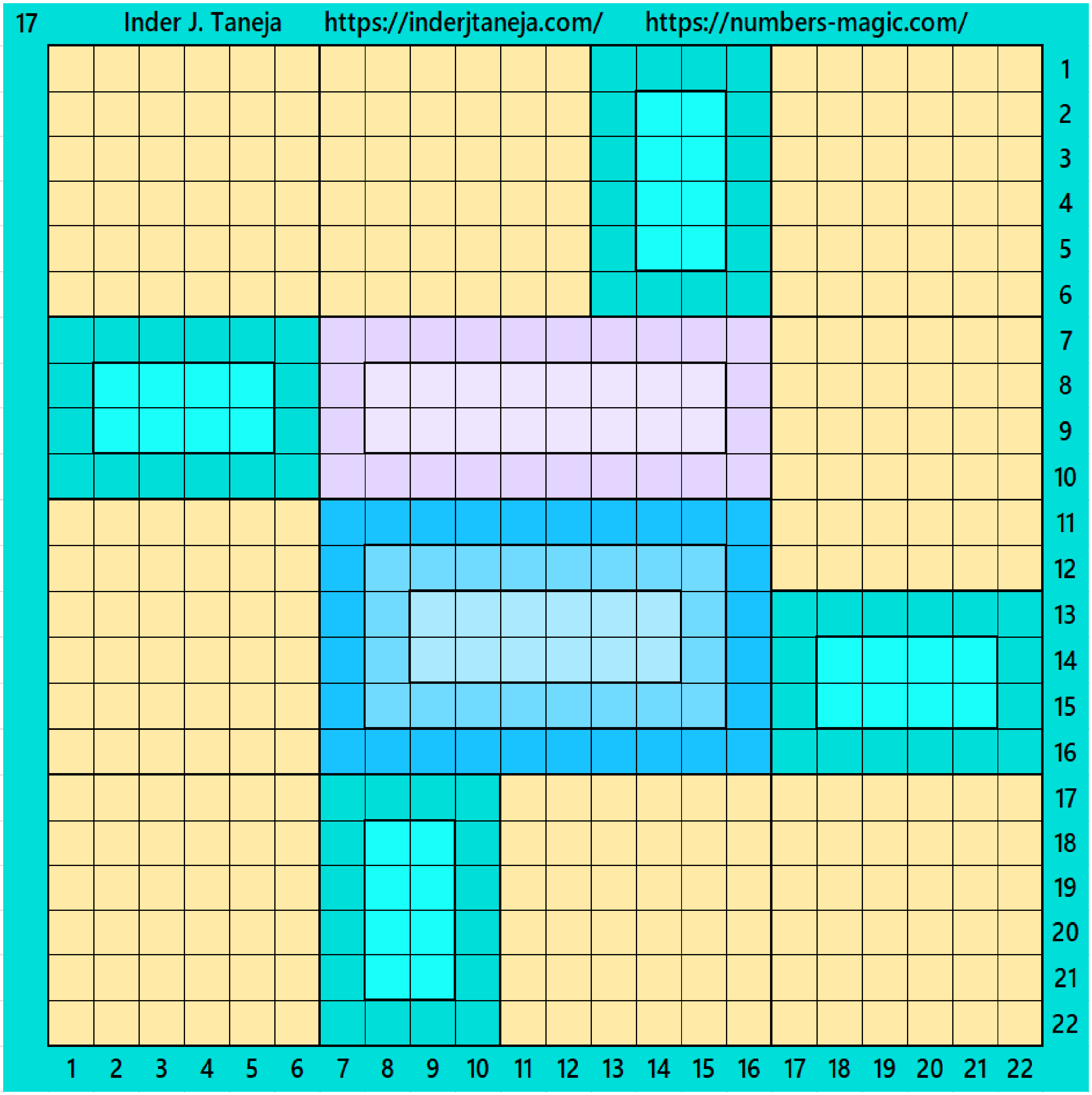
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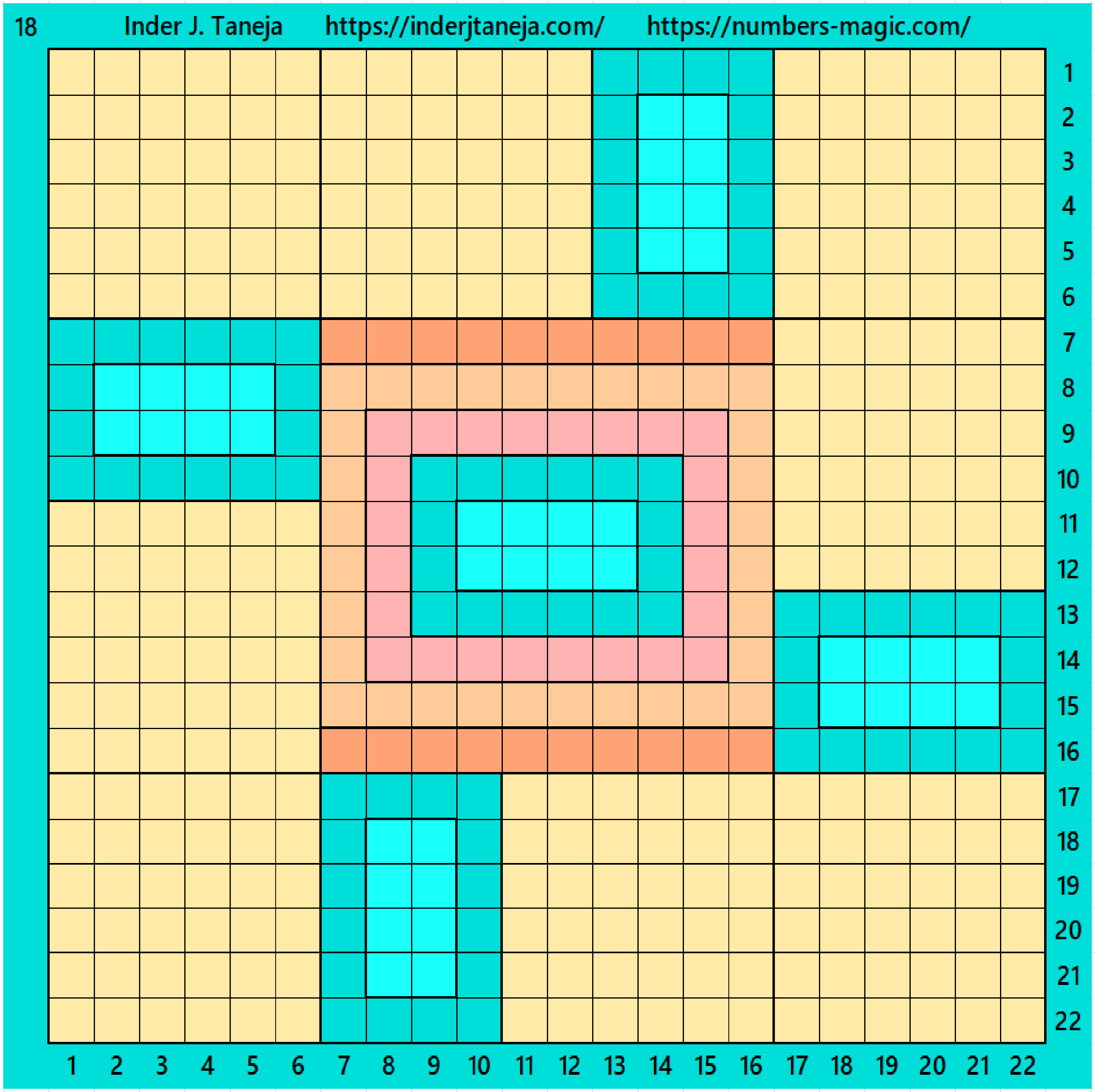
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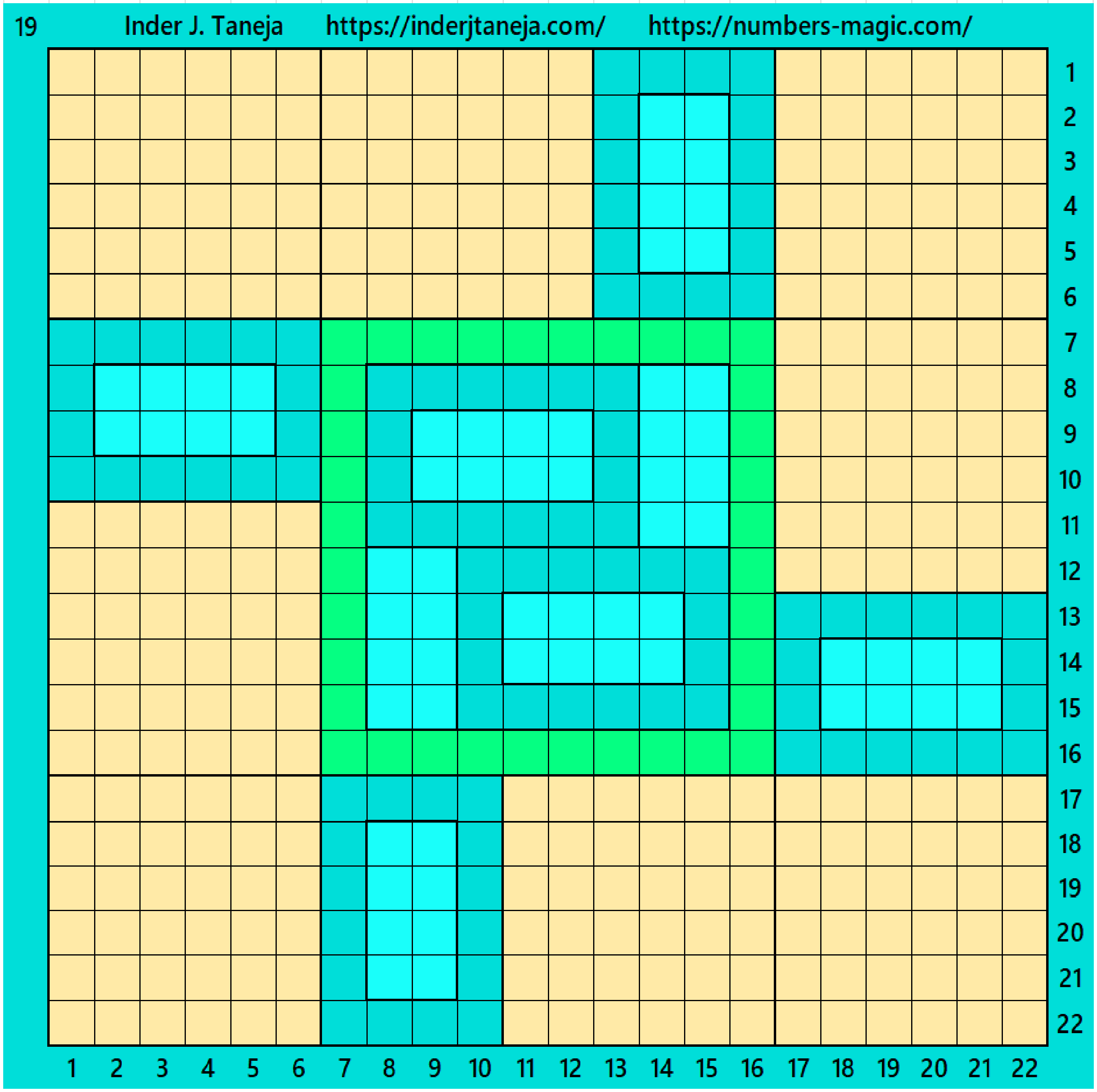
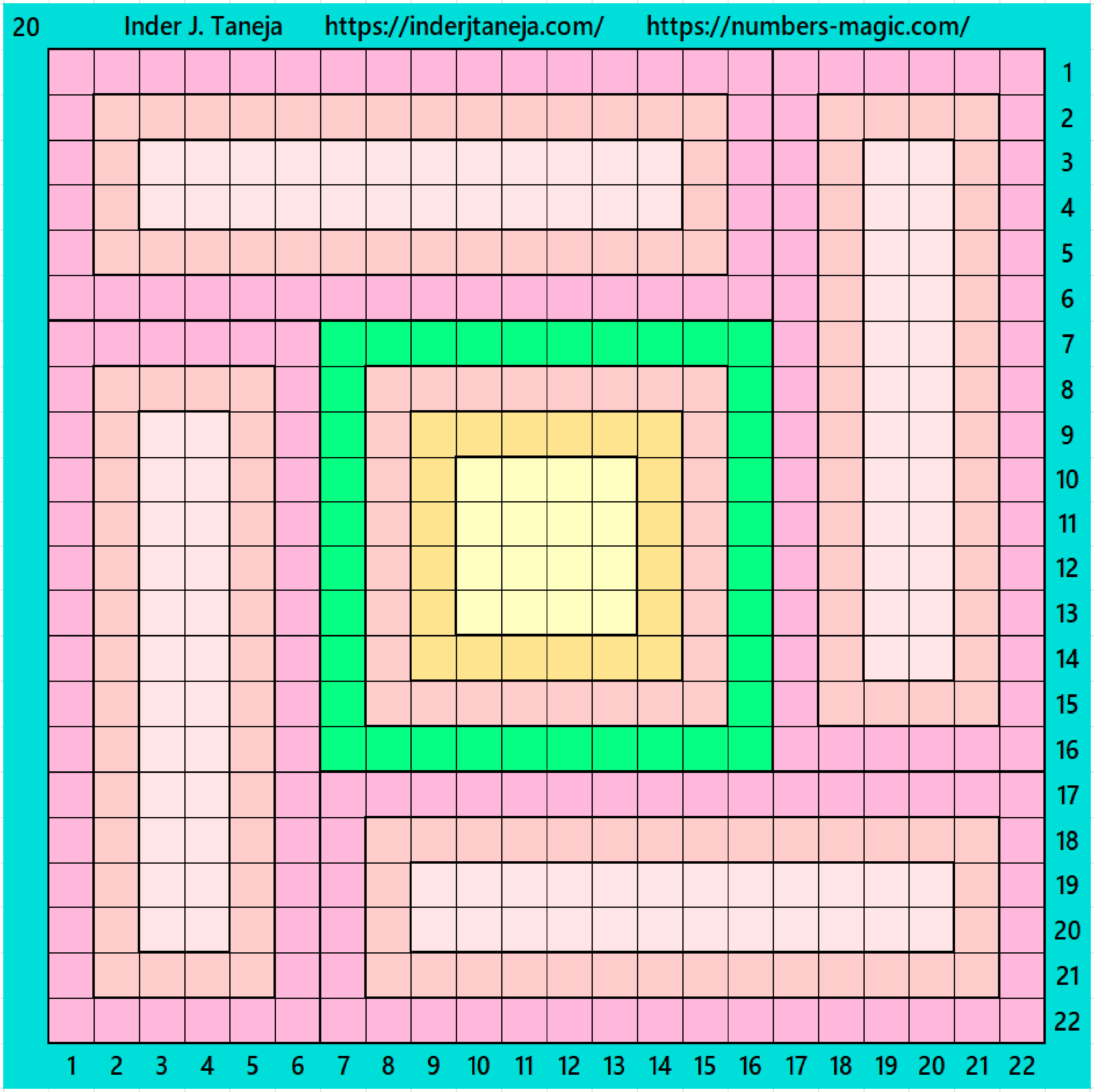
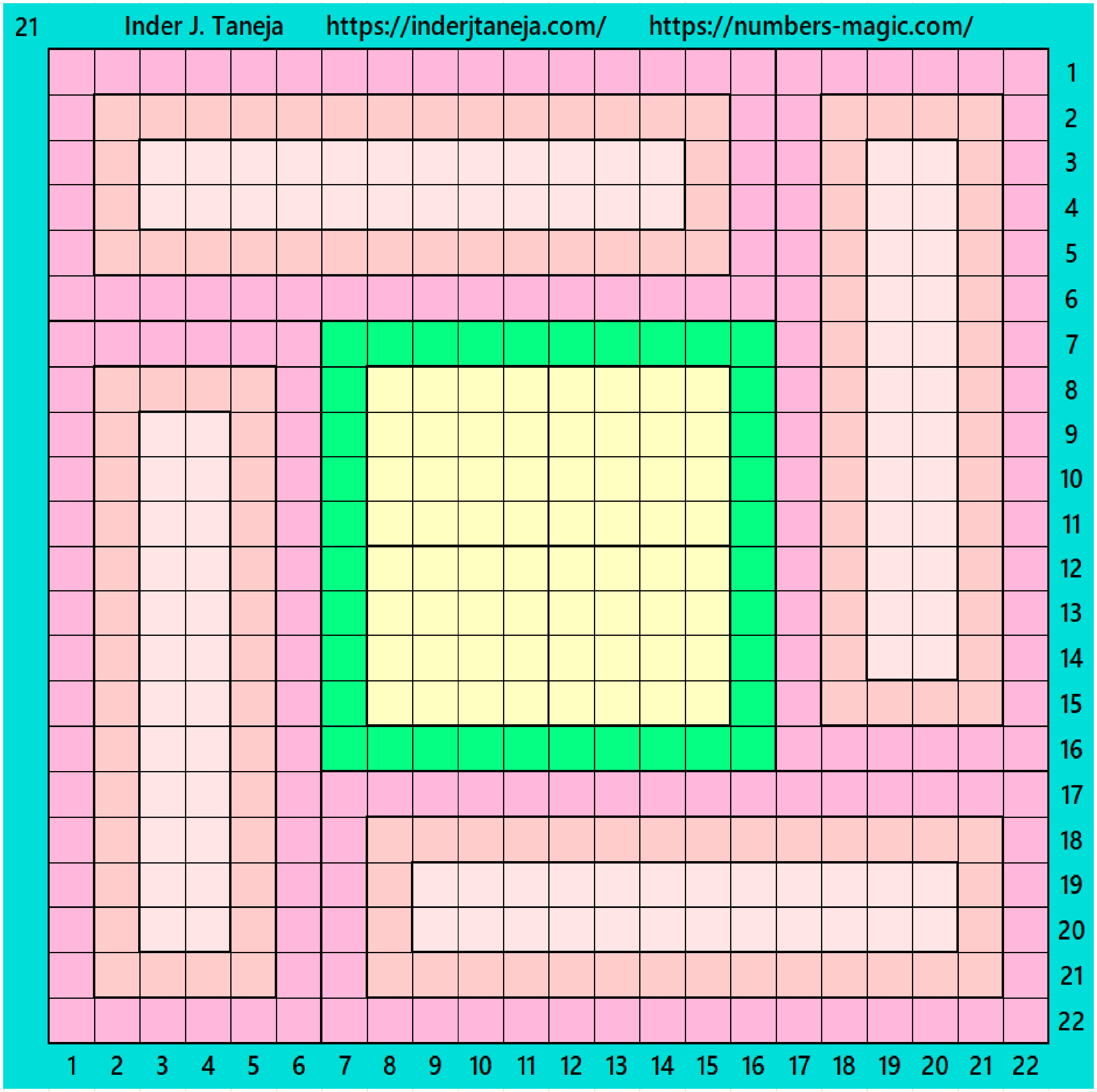


2.6 Closed Border of Order 6

Let's write a closed external border formed by four equal sums BMR's of order 6×16. In the middle we are left with block of order 10. Writing middle block of order 10 with different types of magic squares, we get magic squares of order 22. See below few examples:

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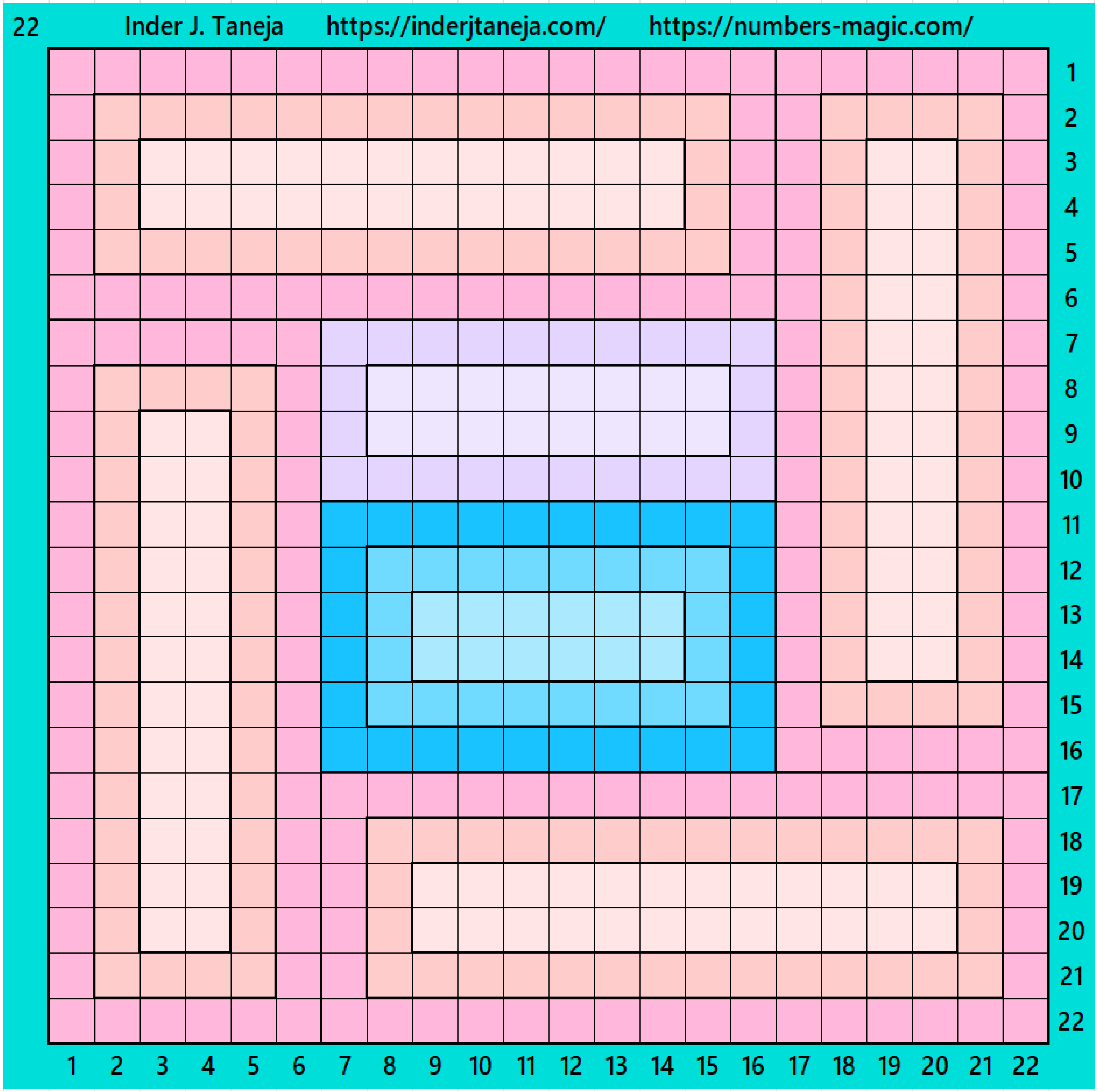
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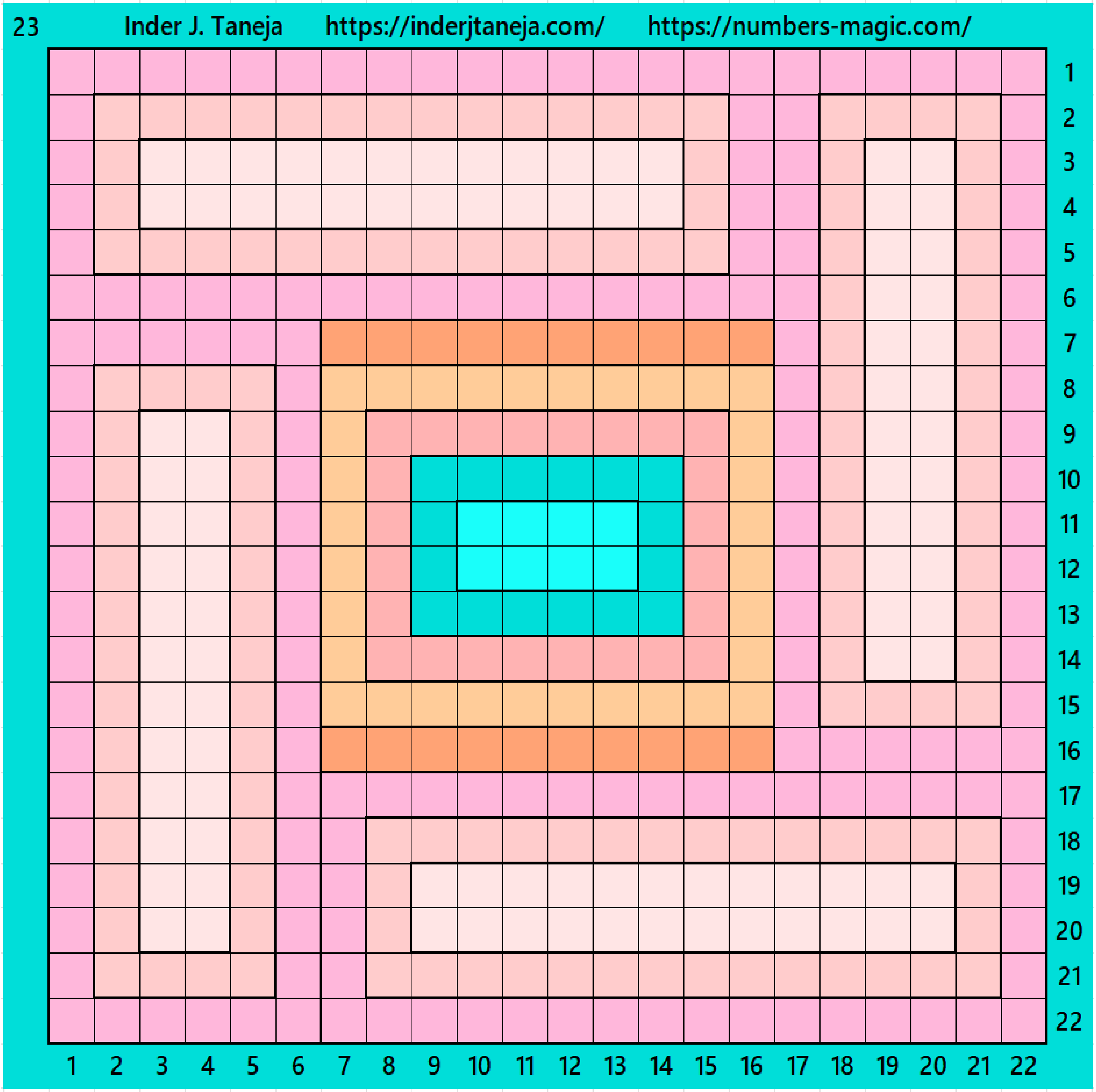
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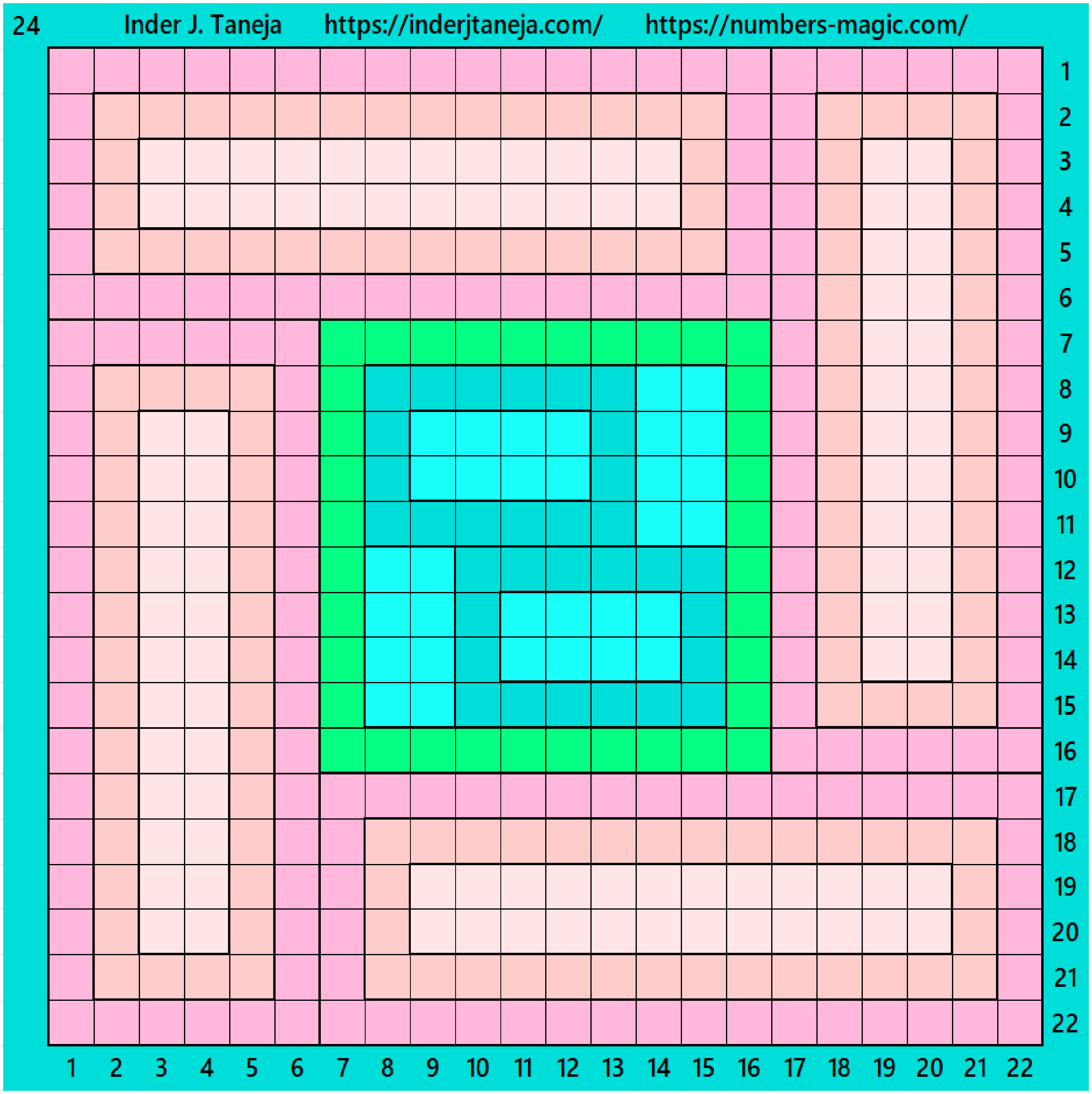
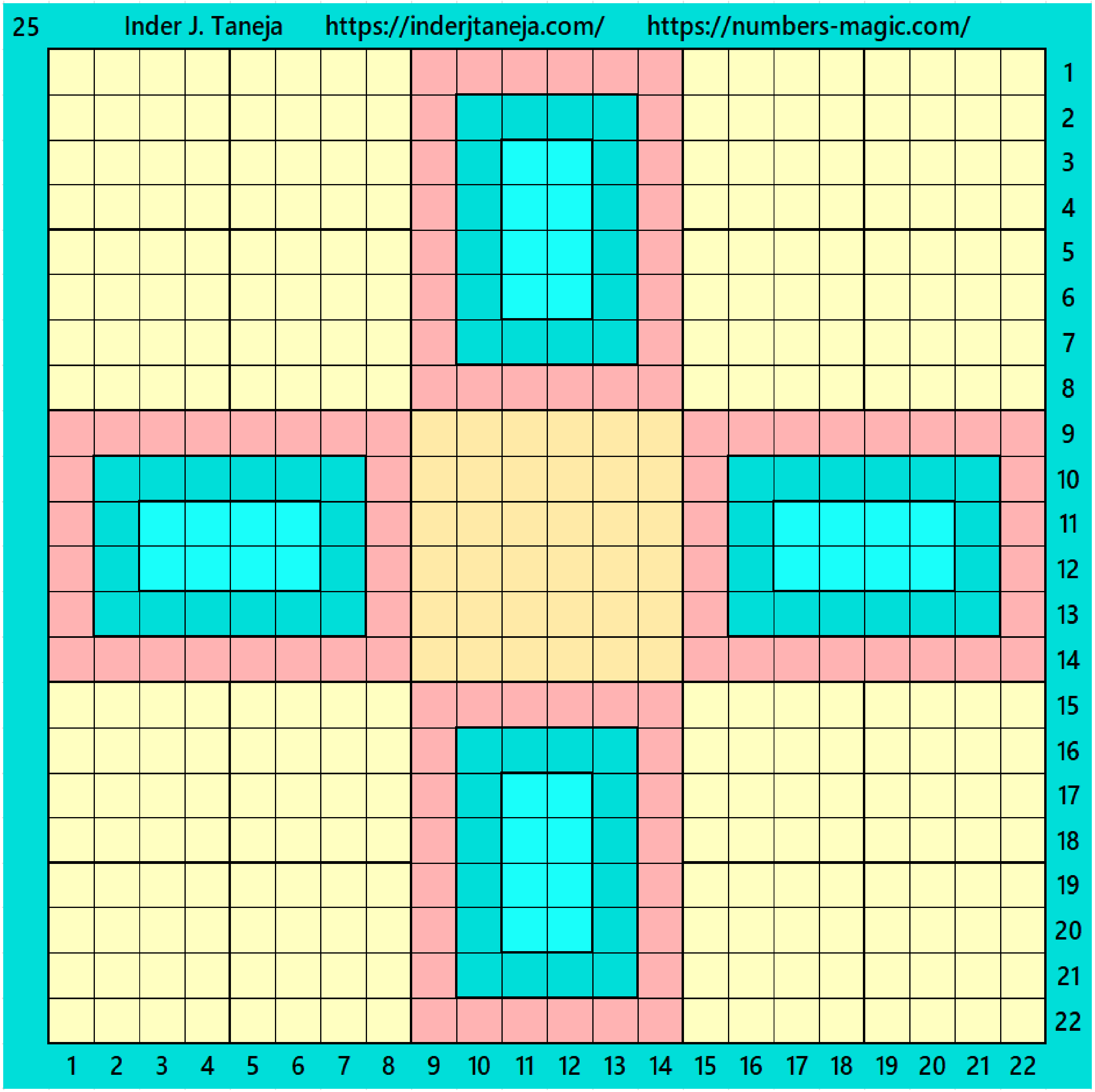
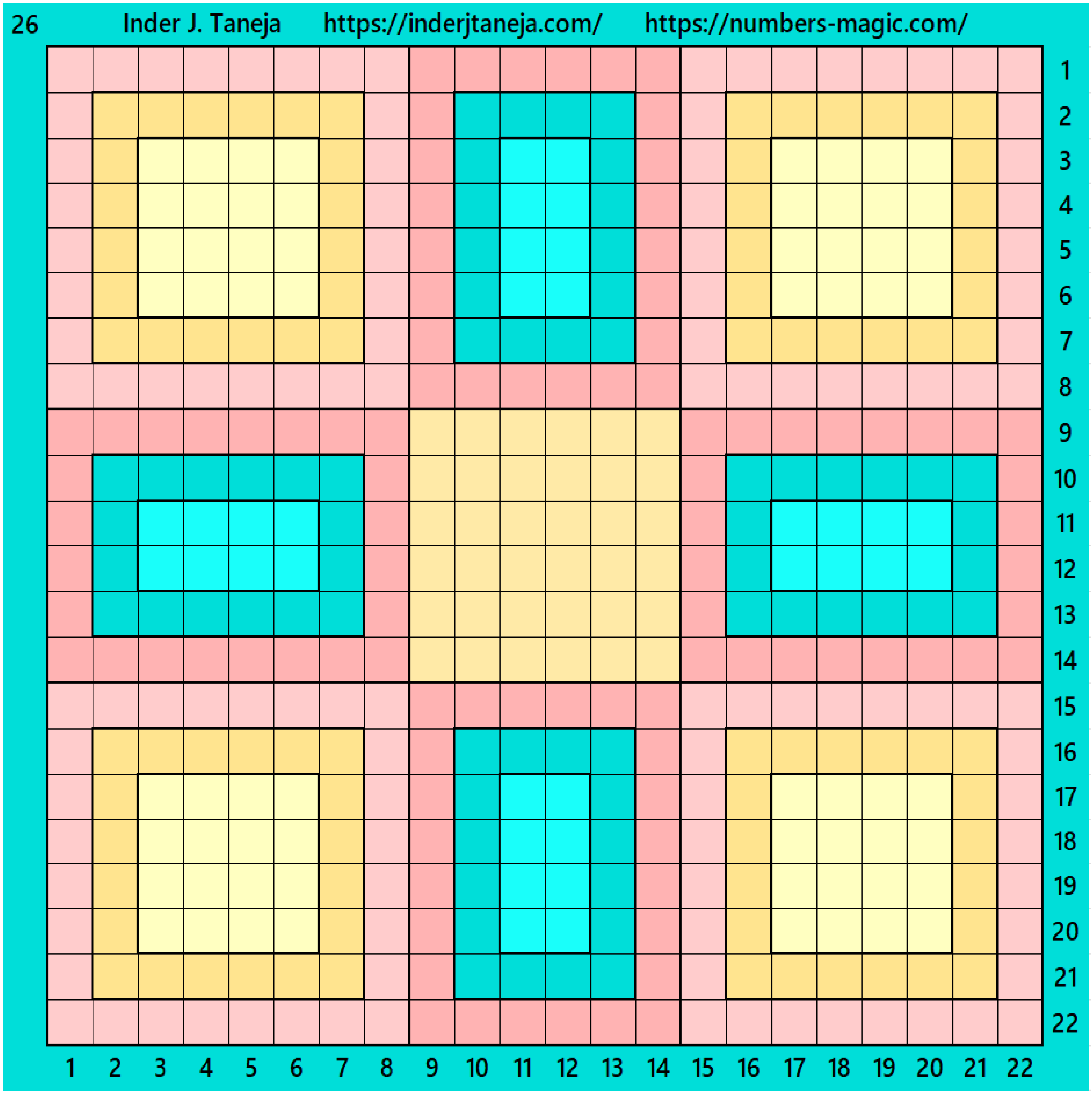


2.7 Cornered Magic Squares of Order 8

Let's consider an external border, where there are 4 magic squares of order 8 at the corners. Let's make an external border by putting BMR of order 6×8 in each row and column. In the

middle we are left with blocks of order 6. Writing middle block of order 6 and different types of magic squares of order 8, we get magic squares of order 22. See below few examples:

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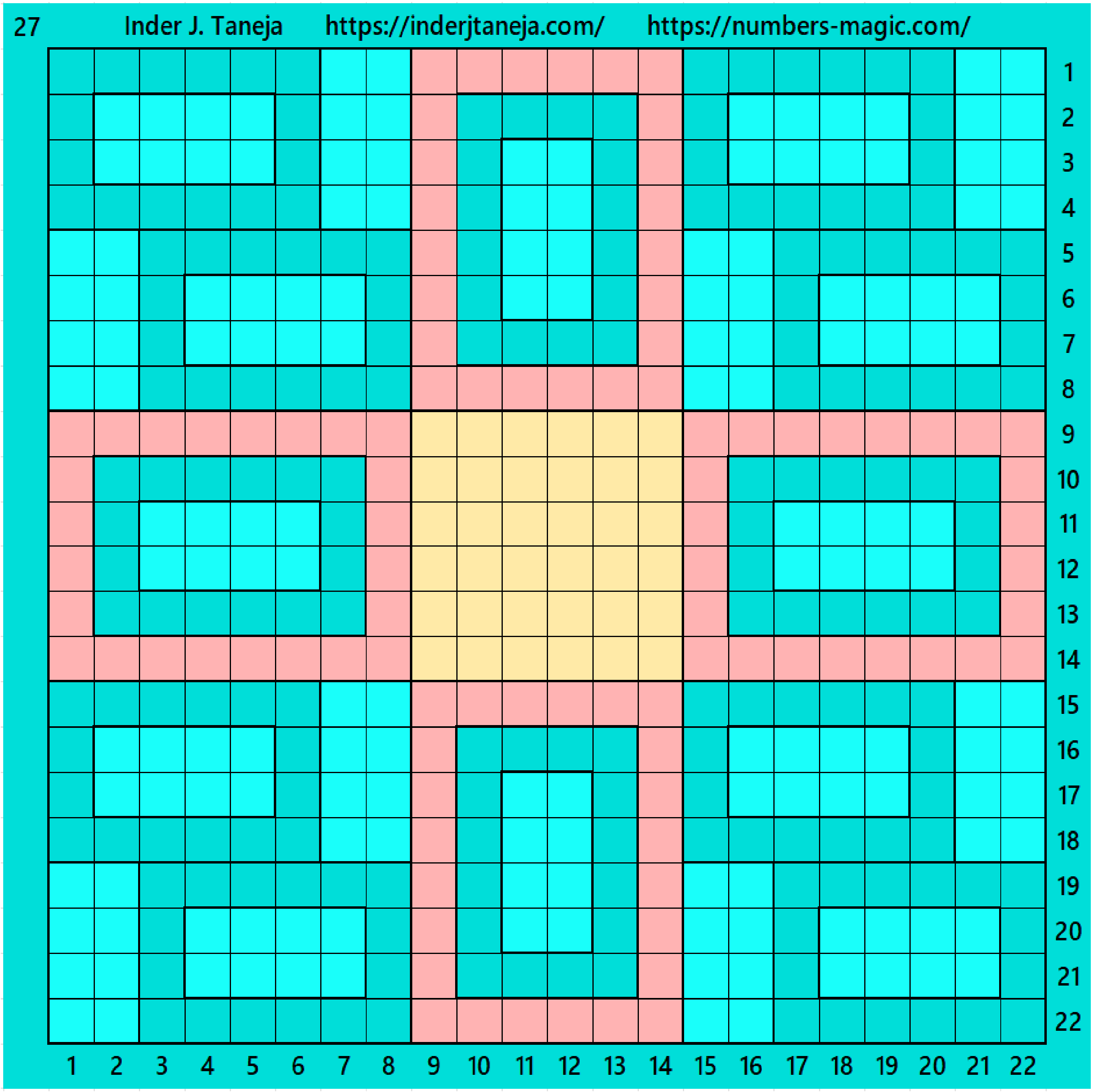
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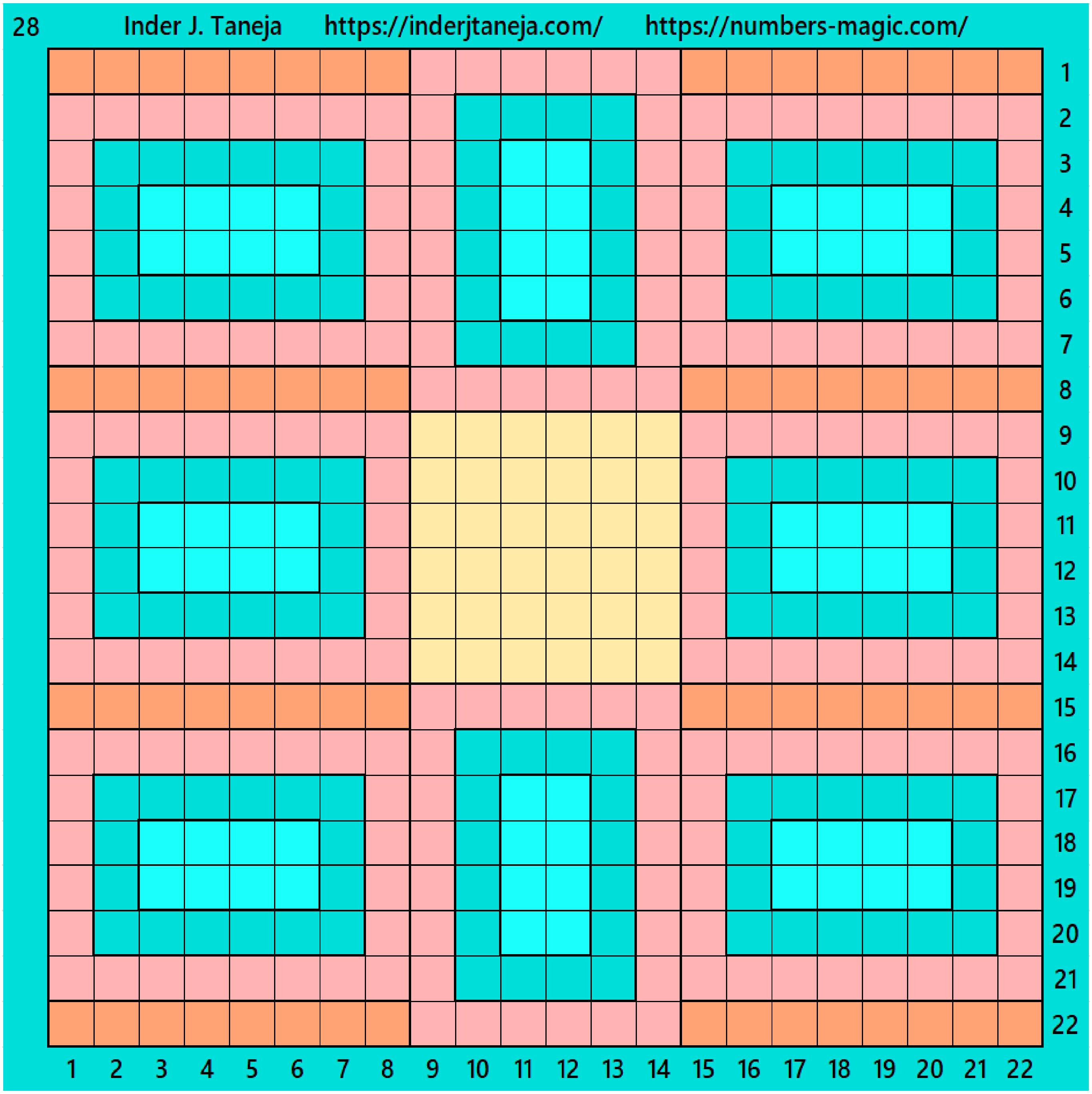
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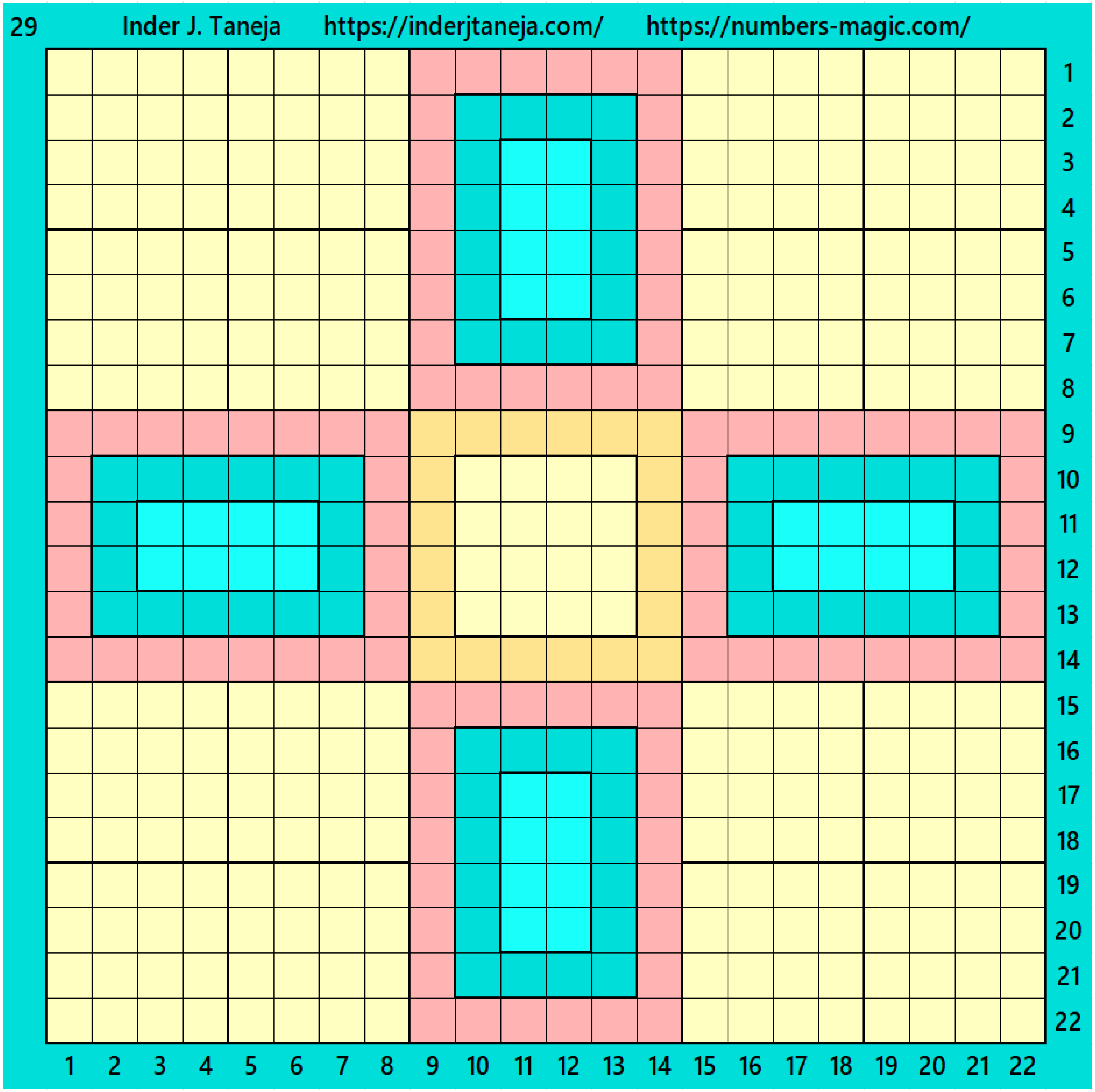
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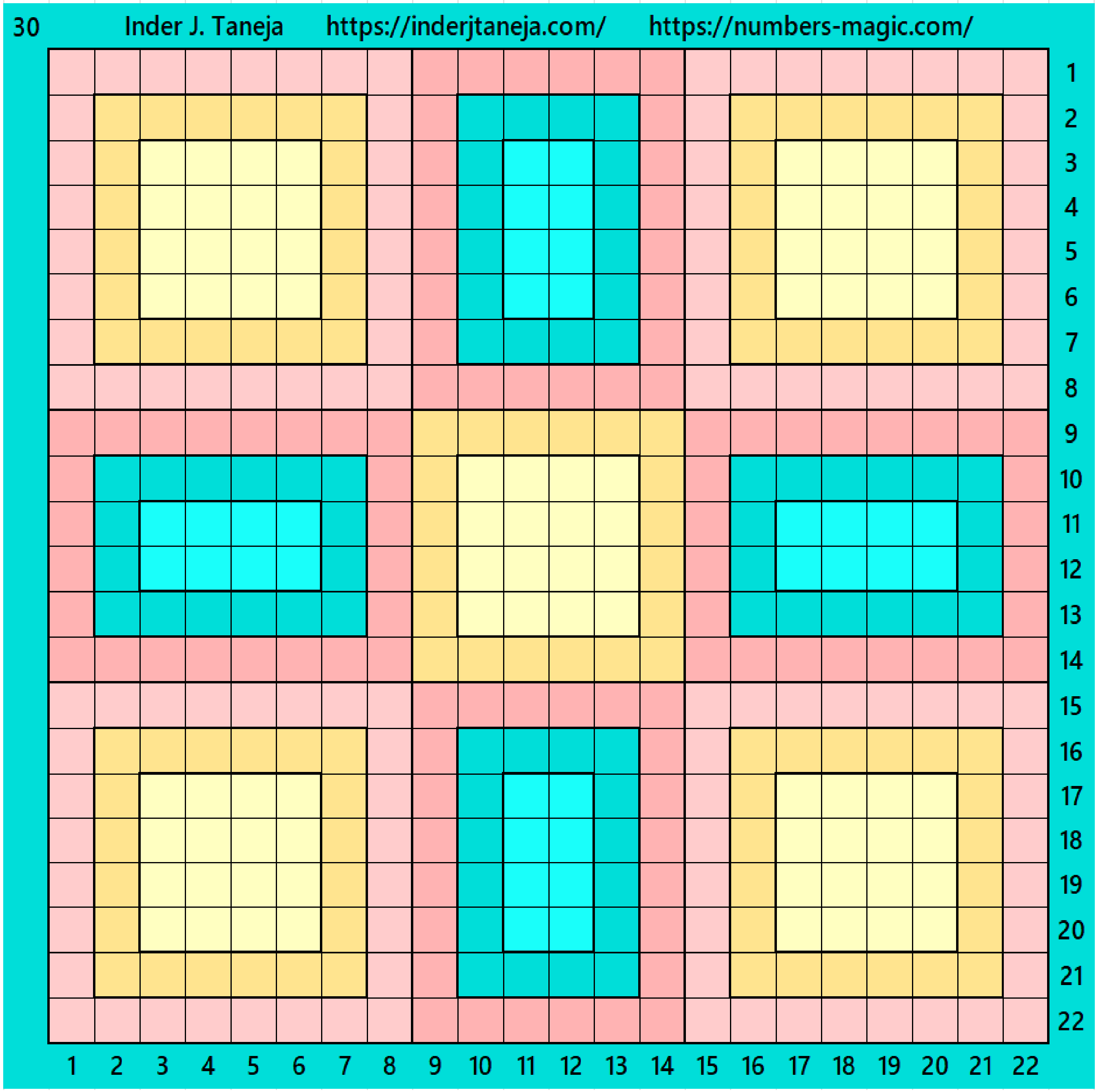
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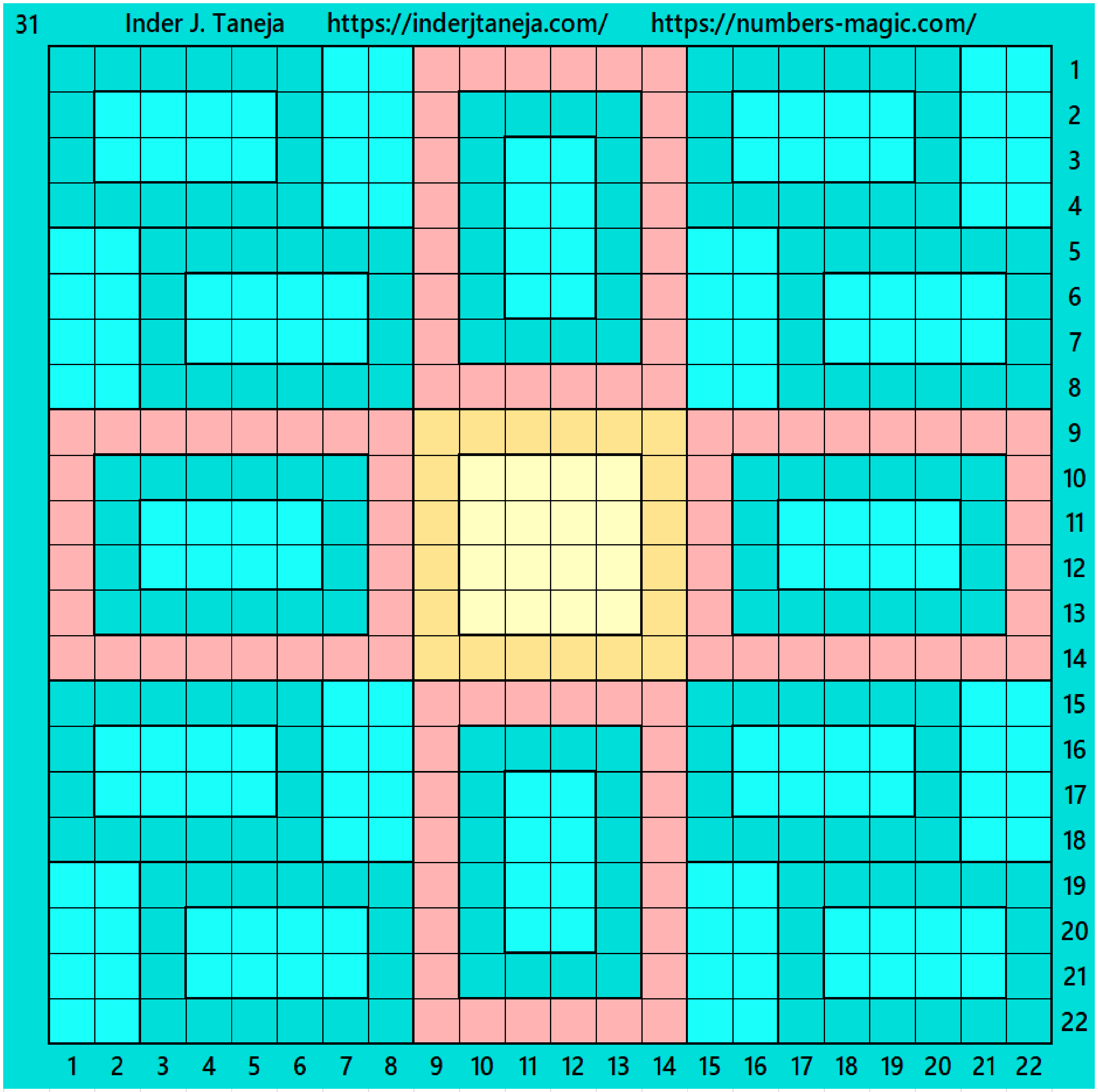
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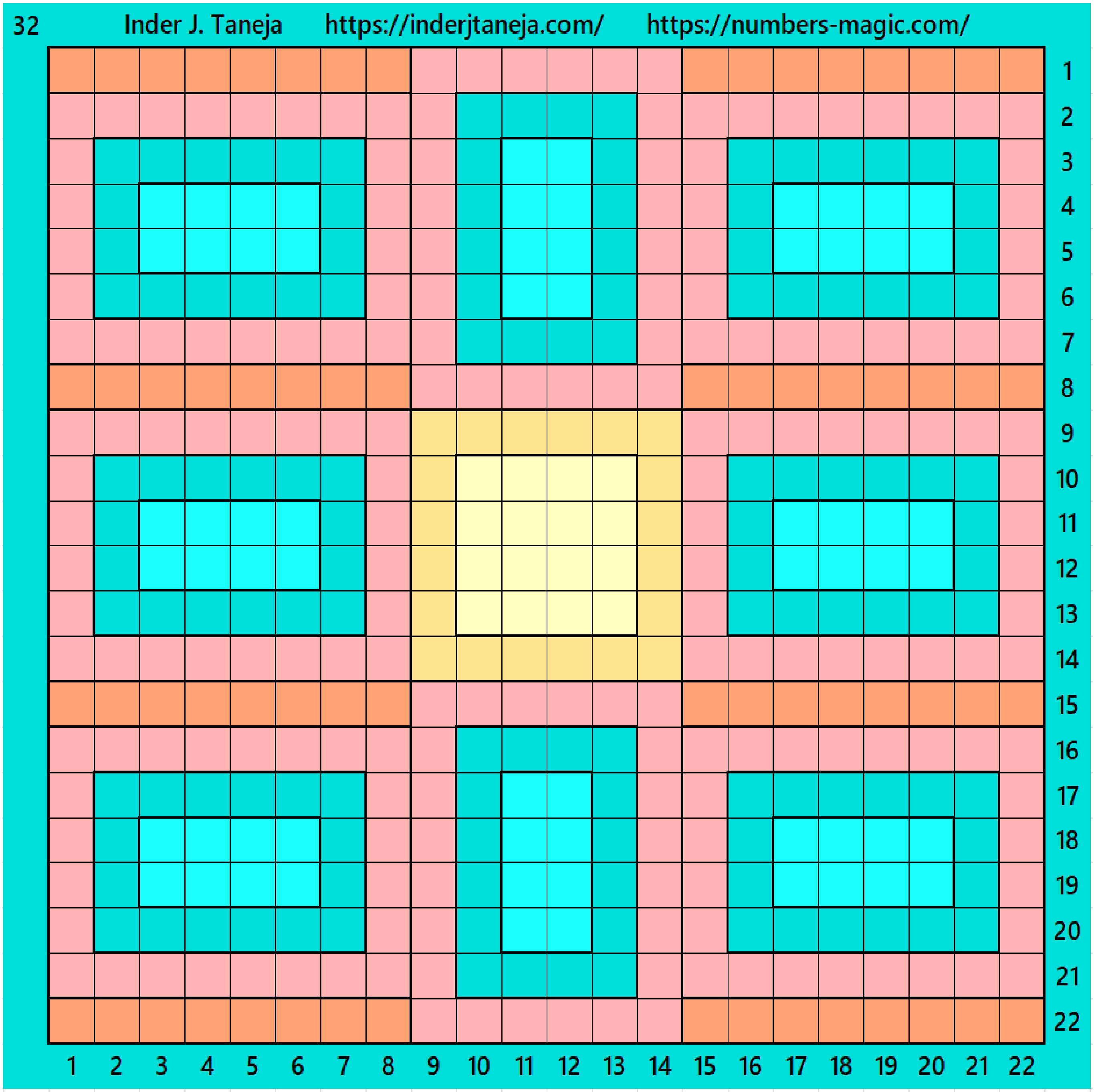
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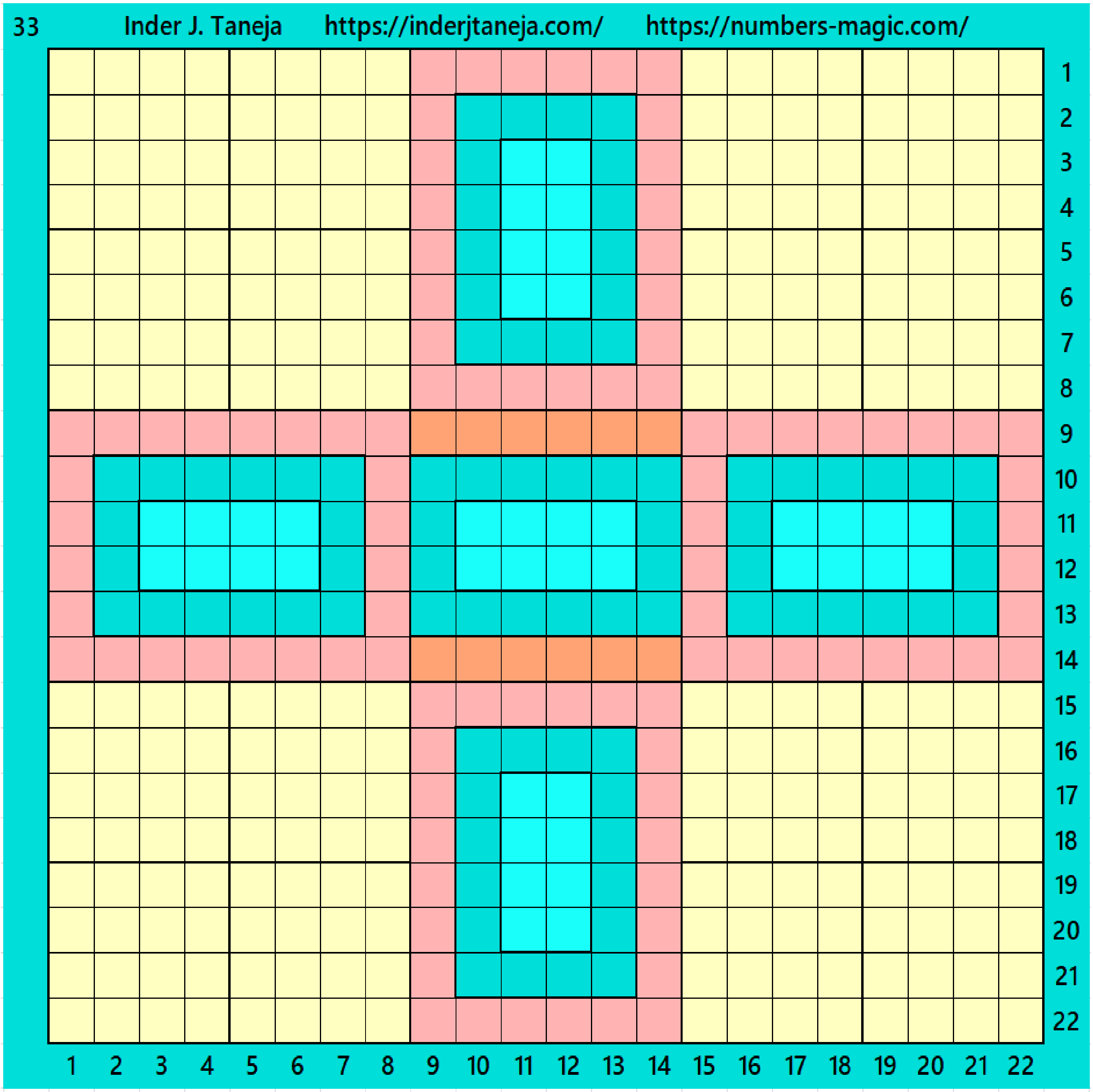
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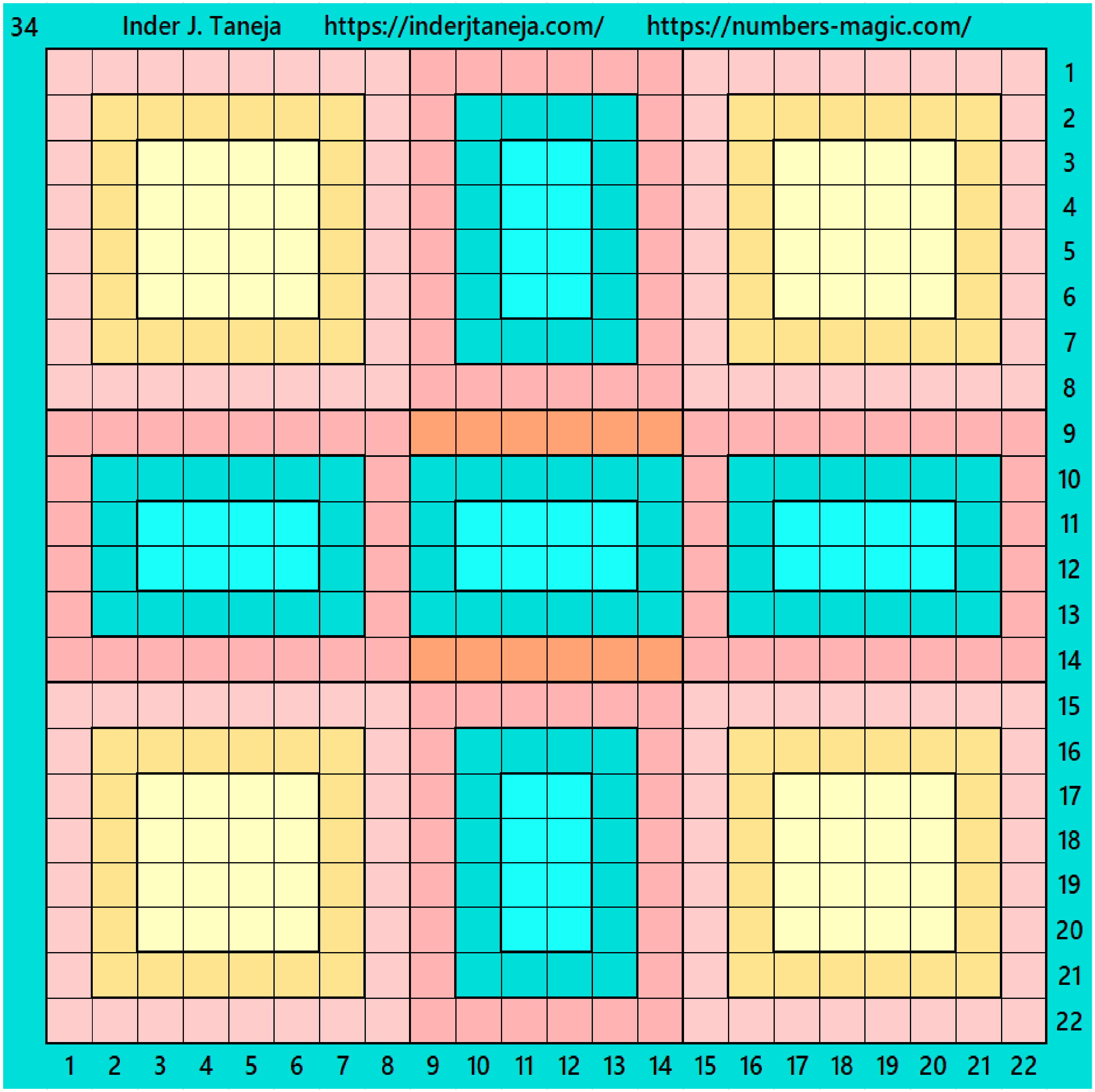
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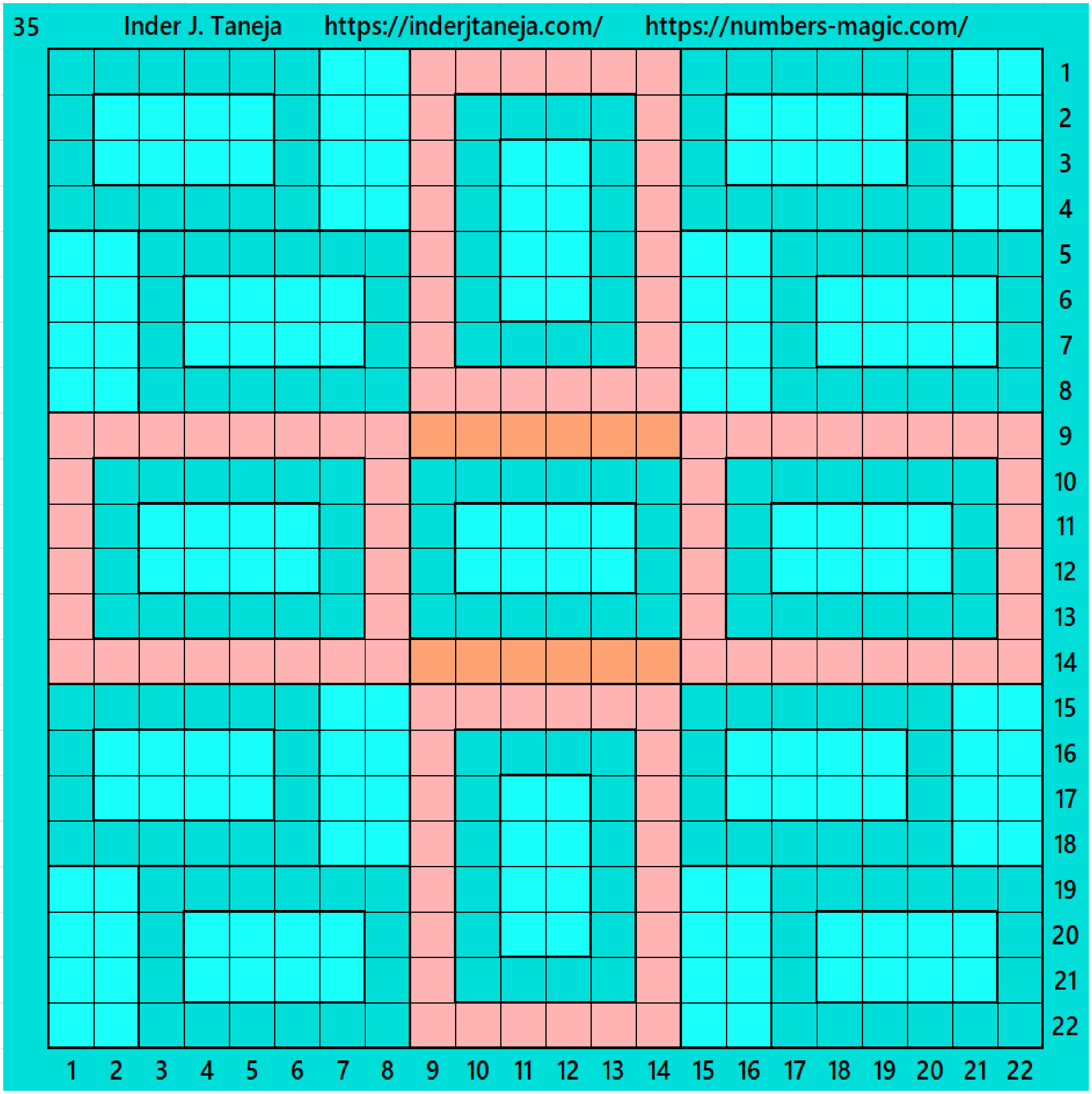
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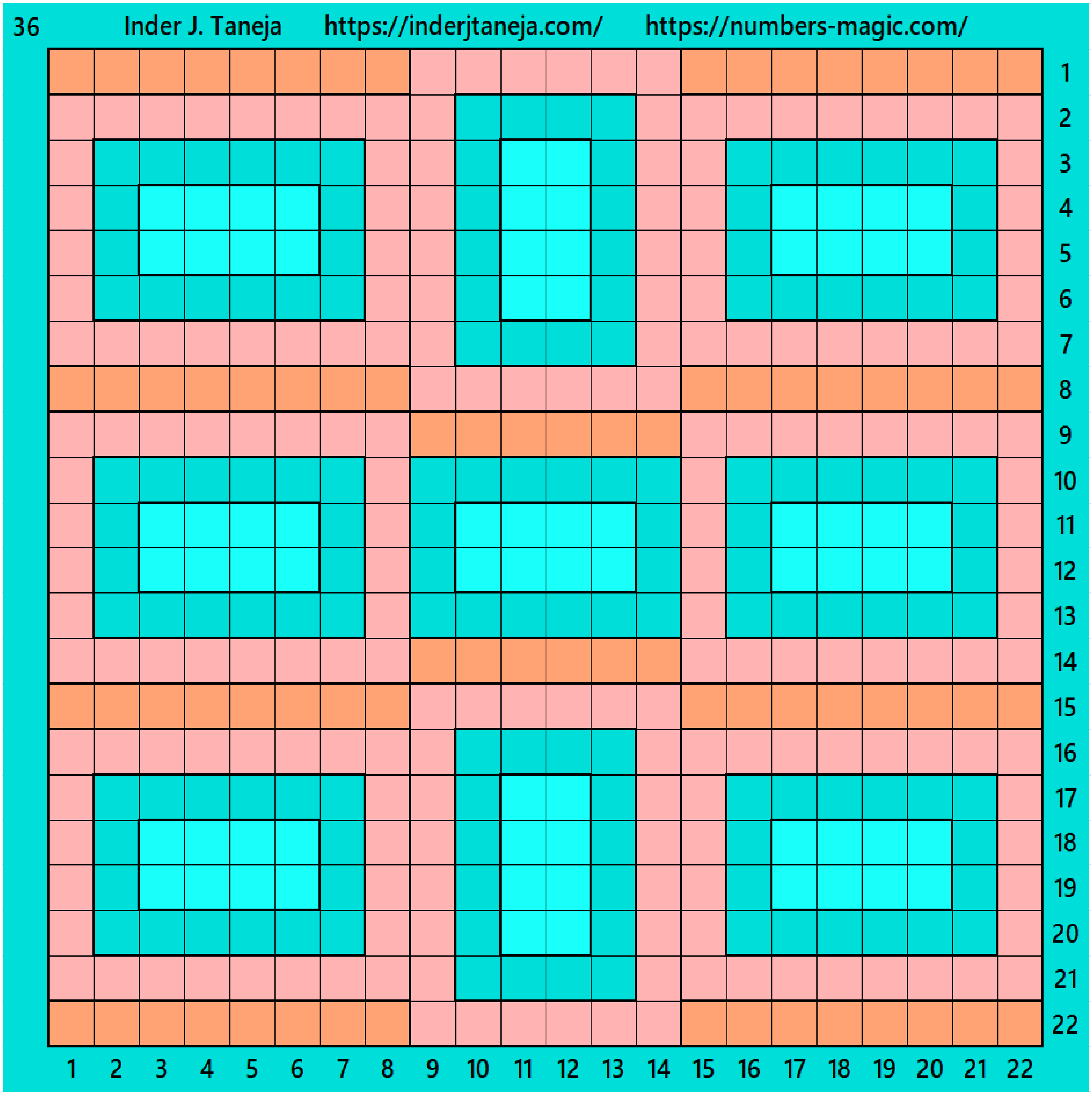
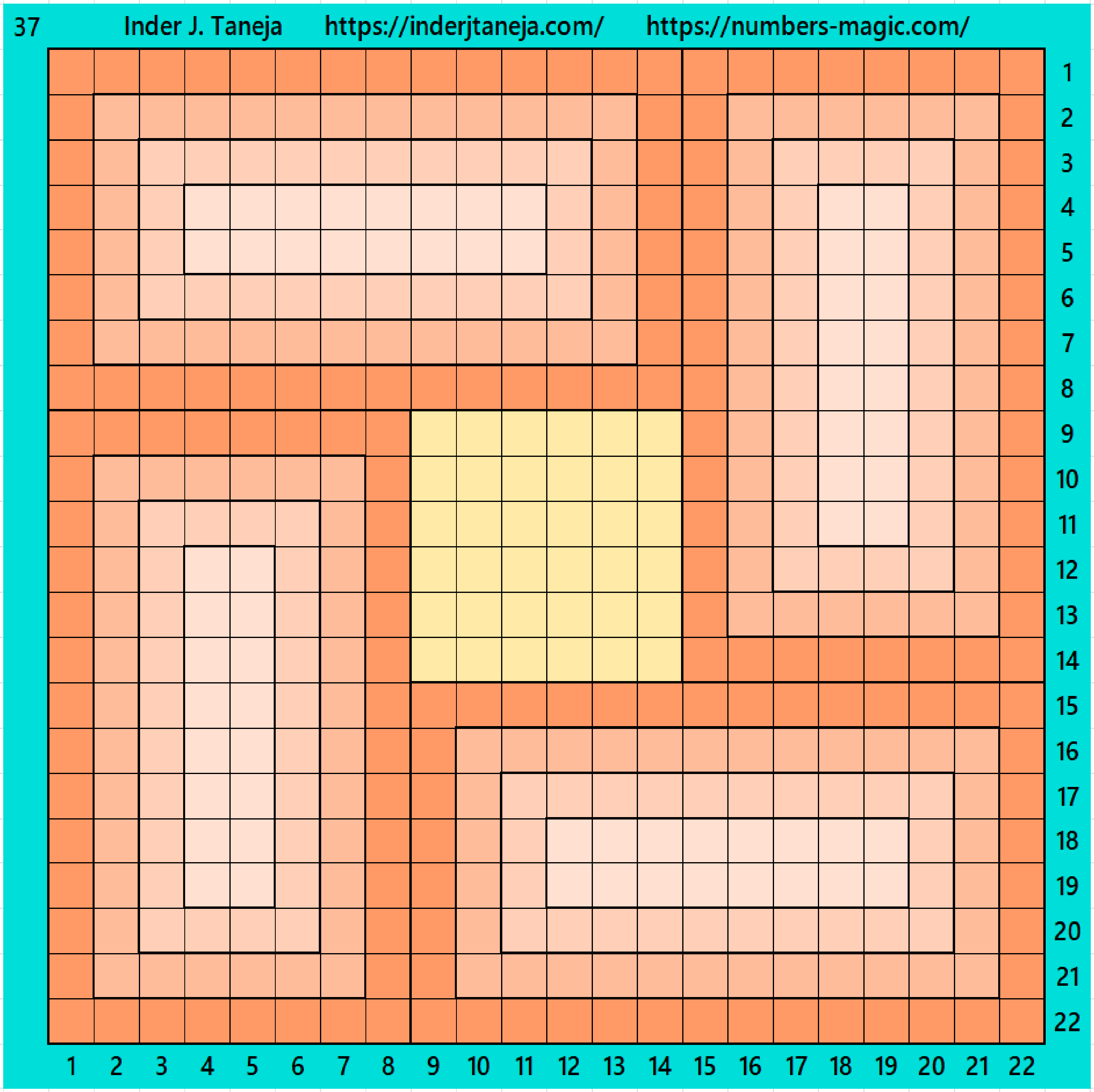
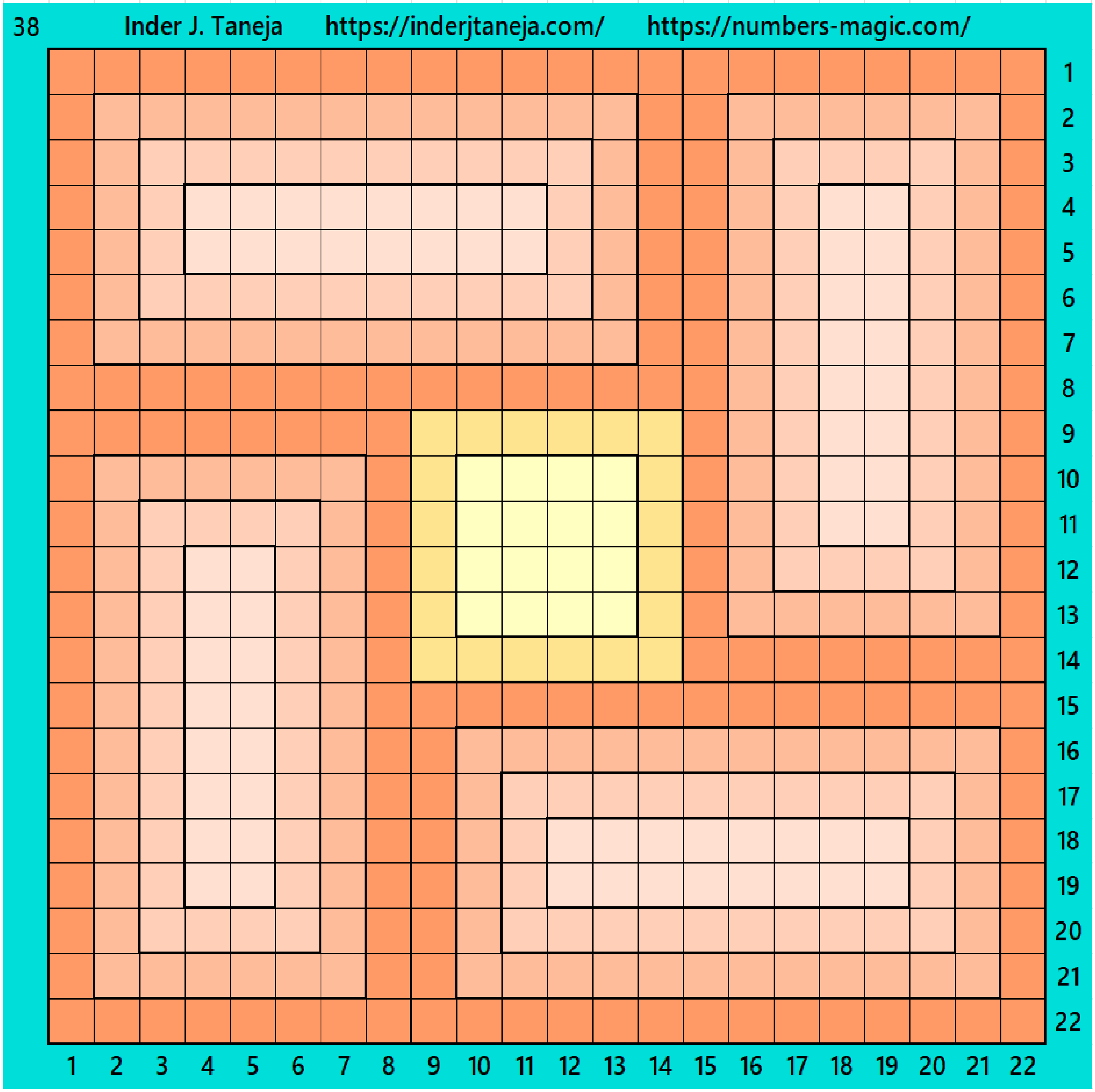


2.8 Closed Border of Order 8

Let's consider an external border, where there are 4 BMR's of order 8×14. Putting them in rows and columns, we get a closed border of order 8. In the middle we are left with blocks of order 6. Writing middle block of order 6 and different types of magic squares of order 8, we get magic squares of order 22. See below few examples:

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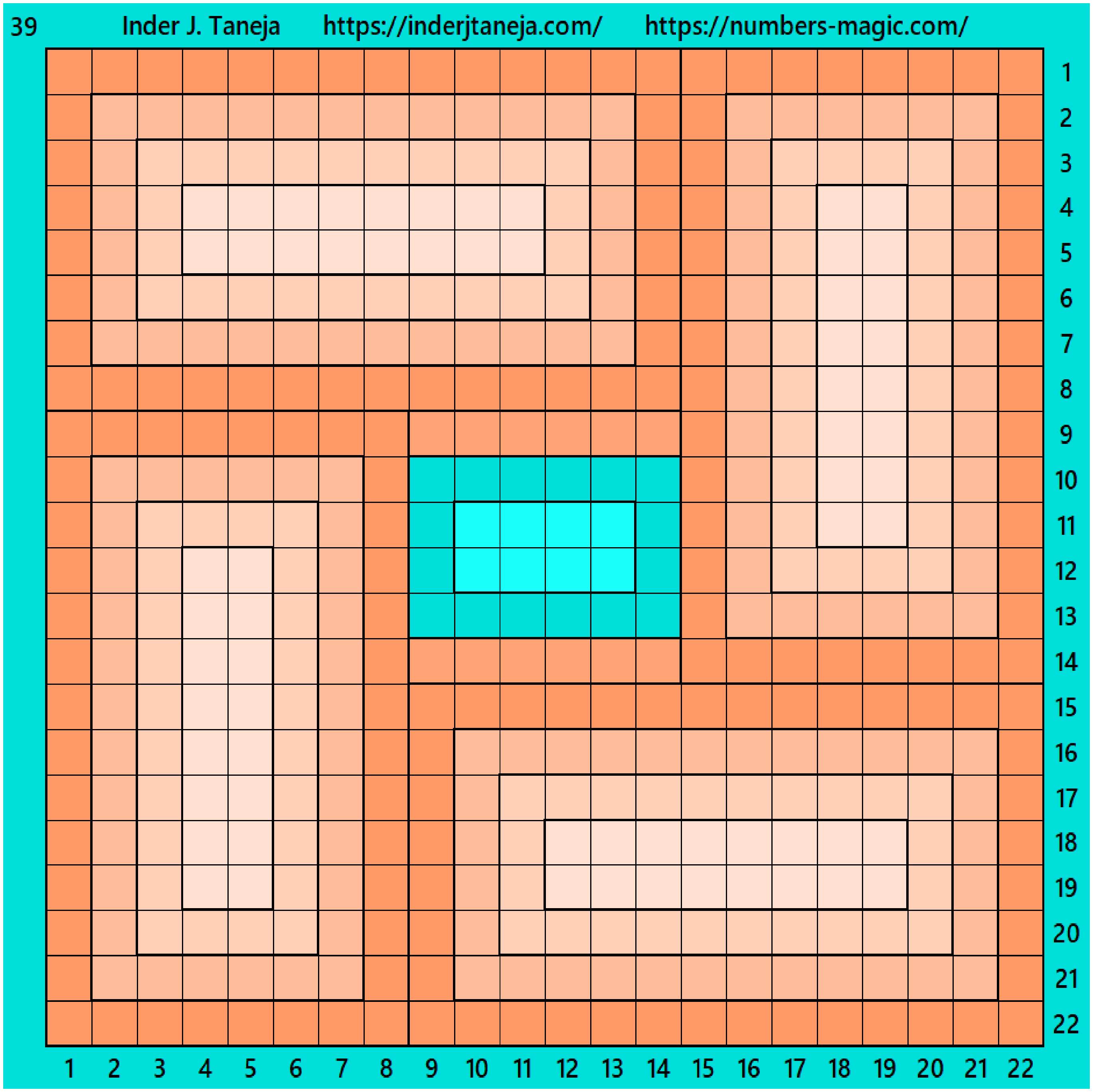
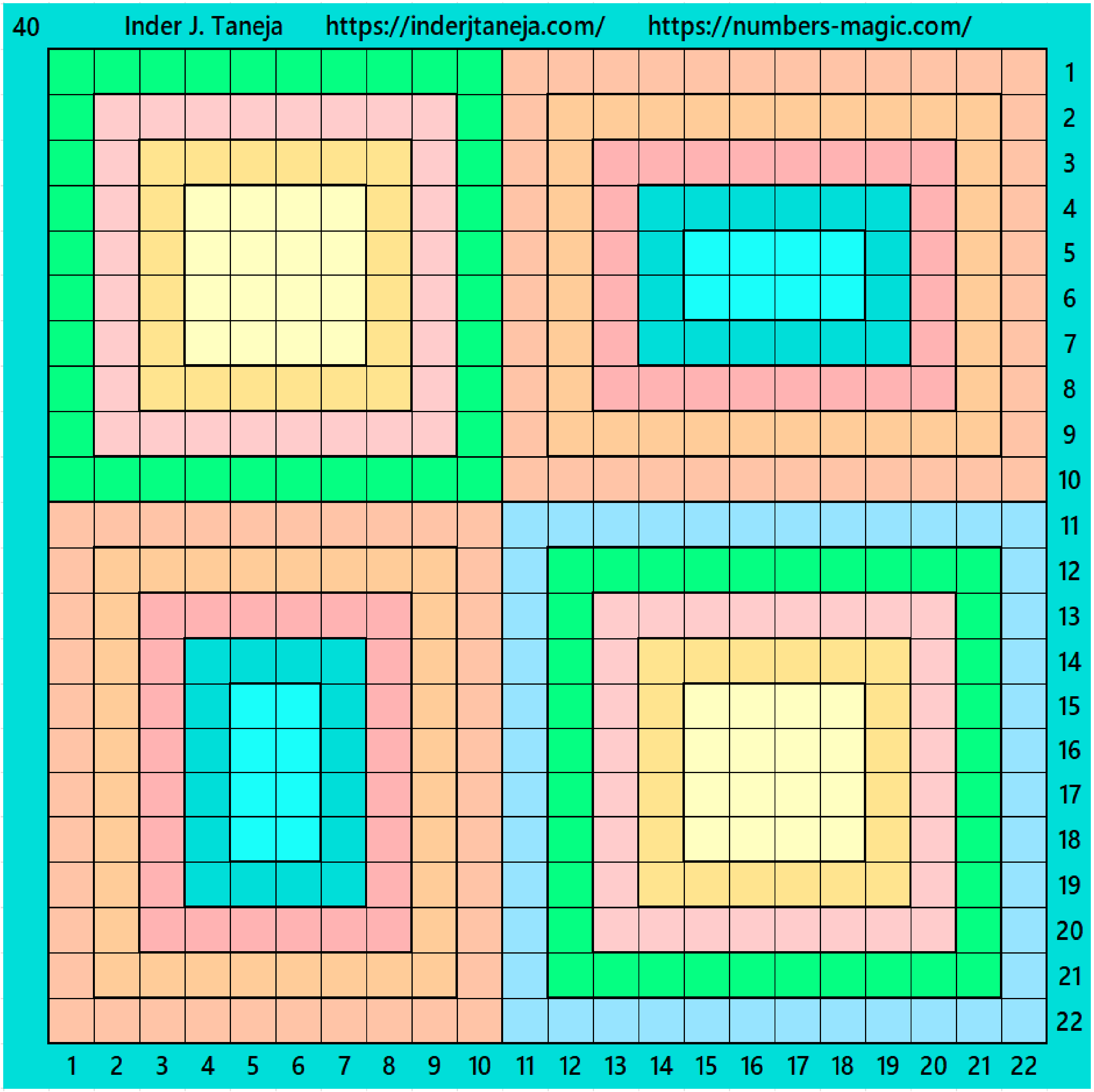


2.9 Blocks of Orderw 10, 12 and BMR's of Order 10×12

Magic squares of orders 10 and 12 with two BMR's of order 10×12 lead us to very interesting magic squares of order 22. See below few examples: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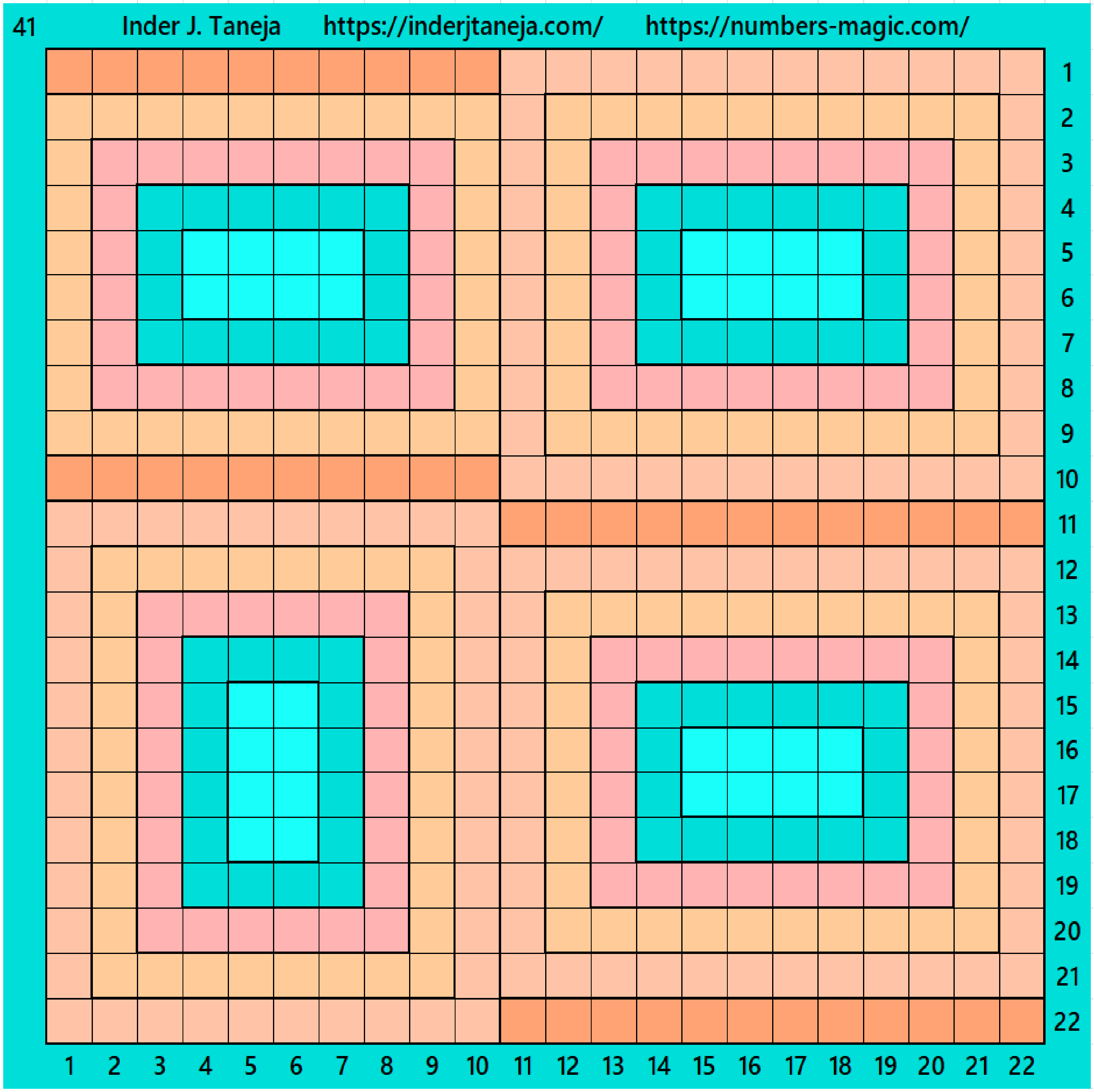
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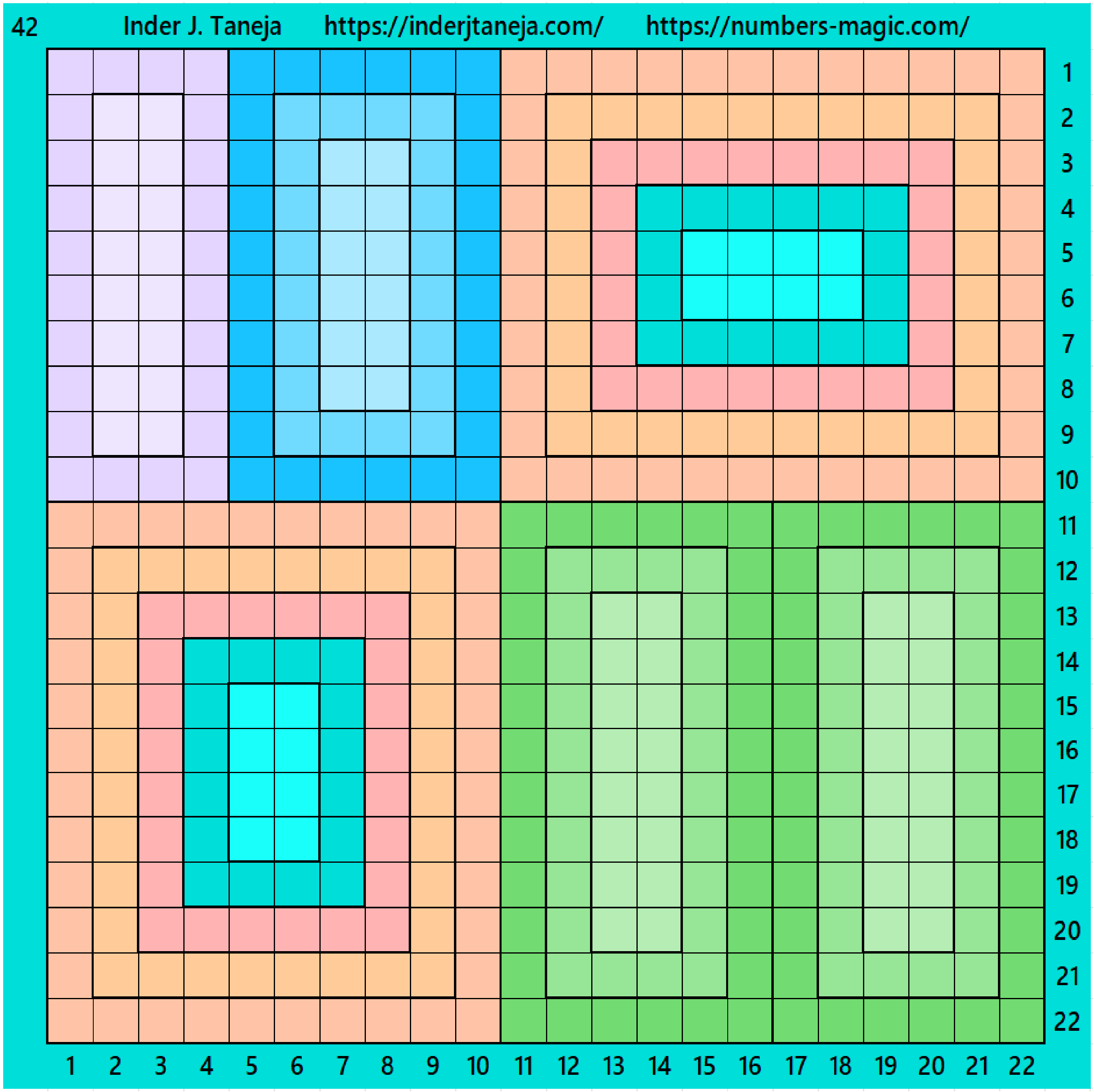
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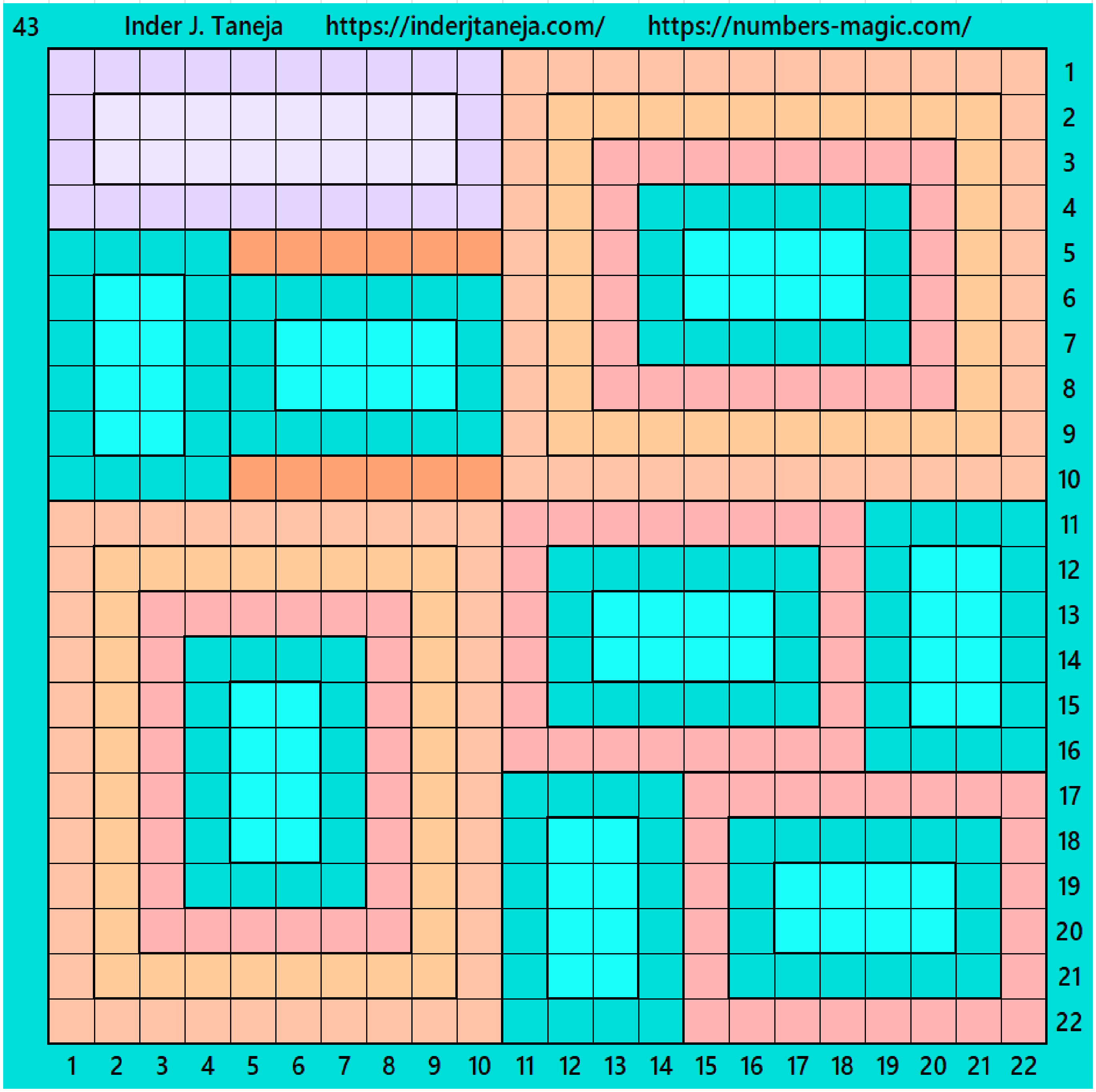
43
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https://inderjtaneja.com/
https://numbers-magic.com/
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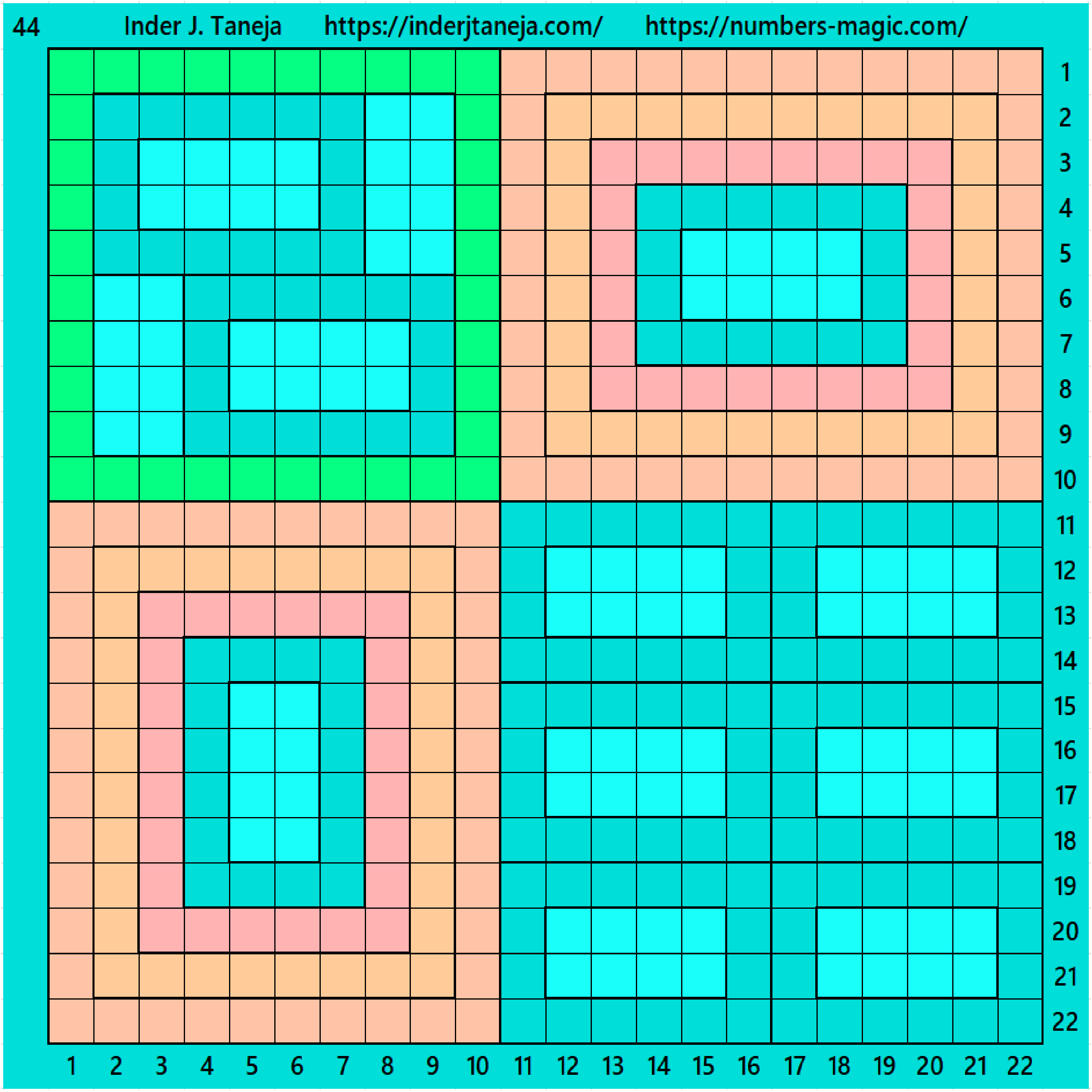
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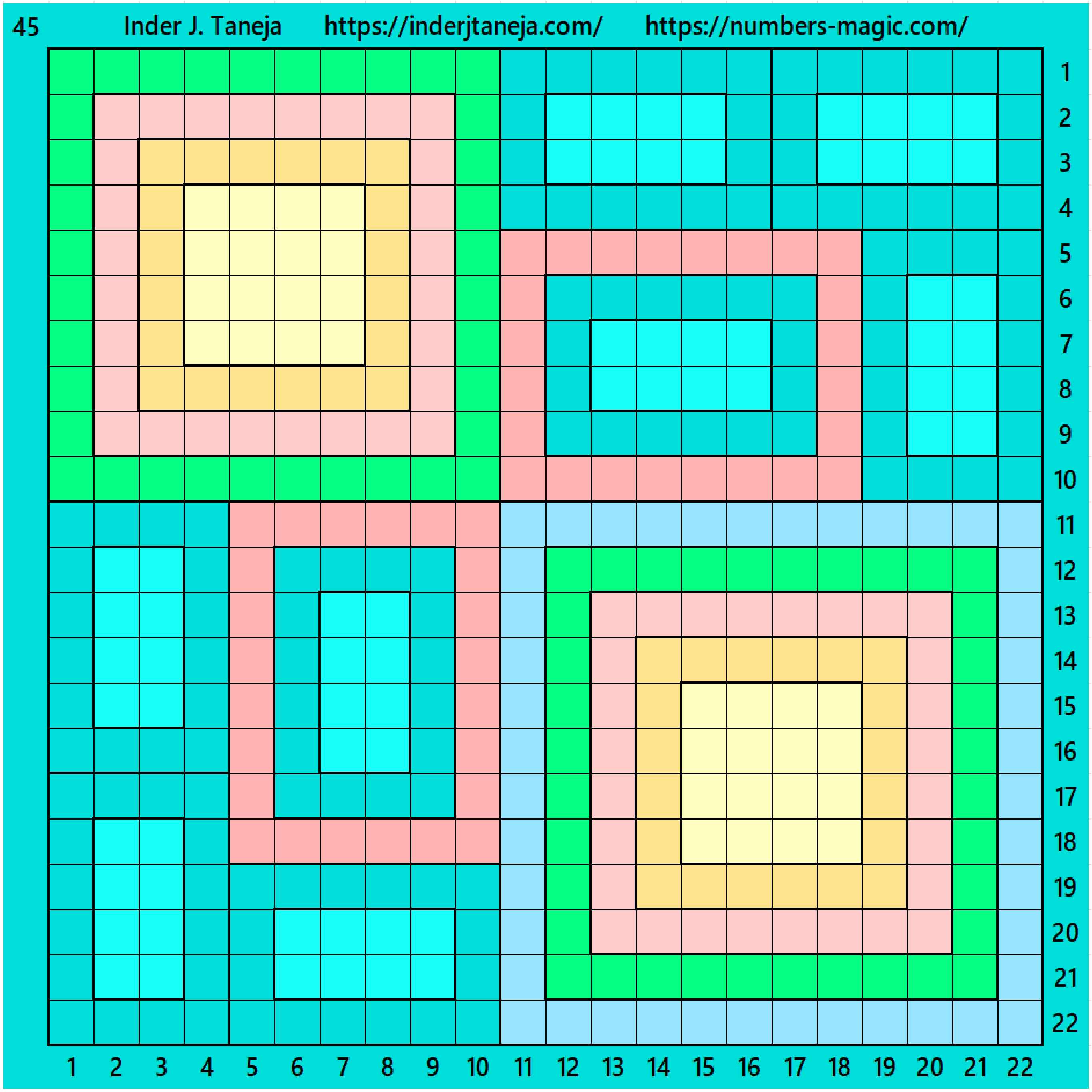
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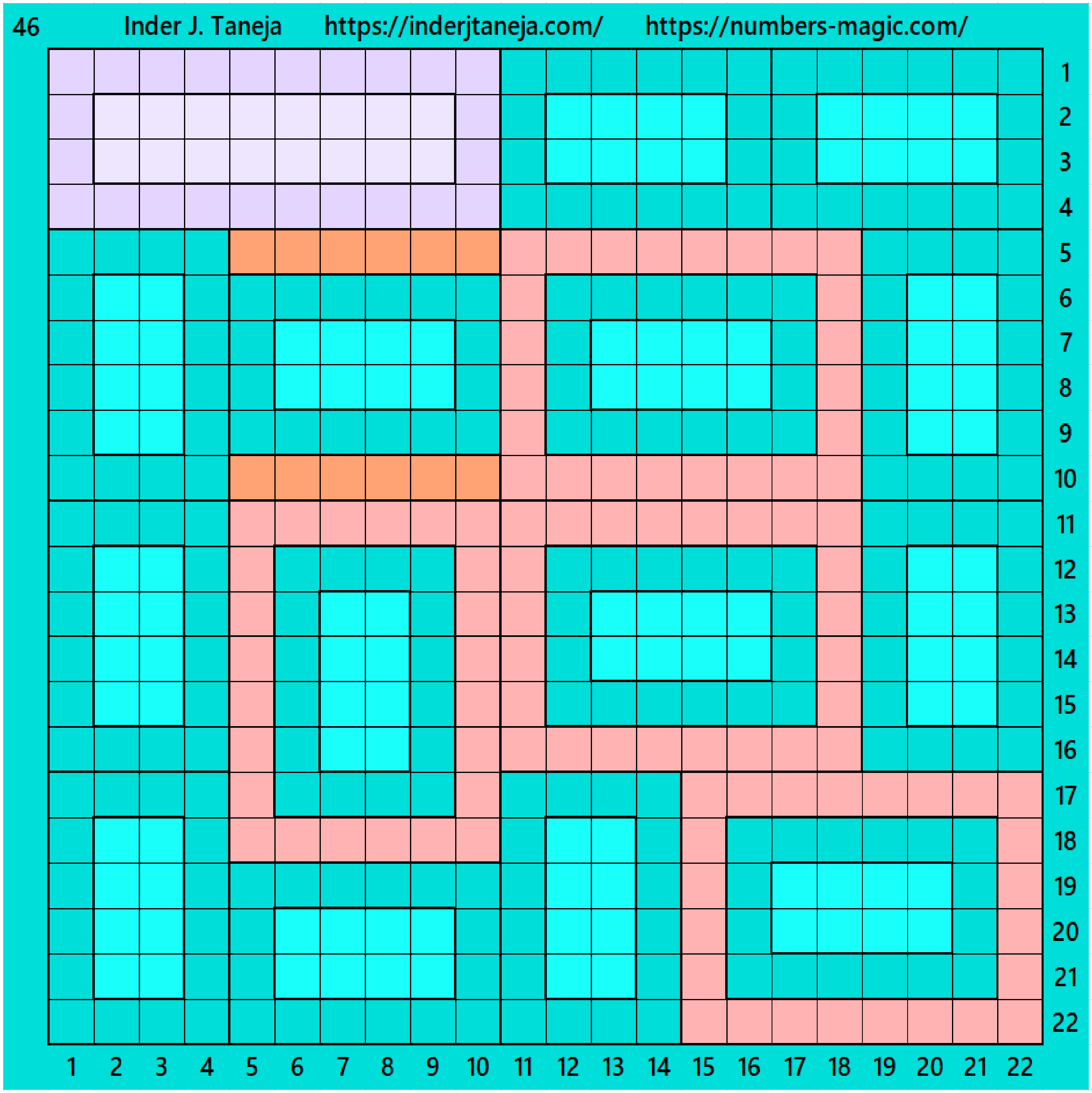
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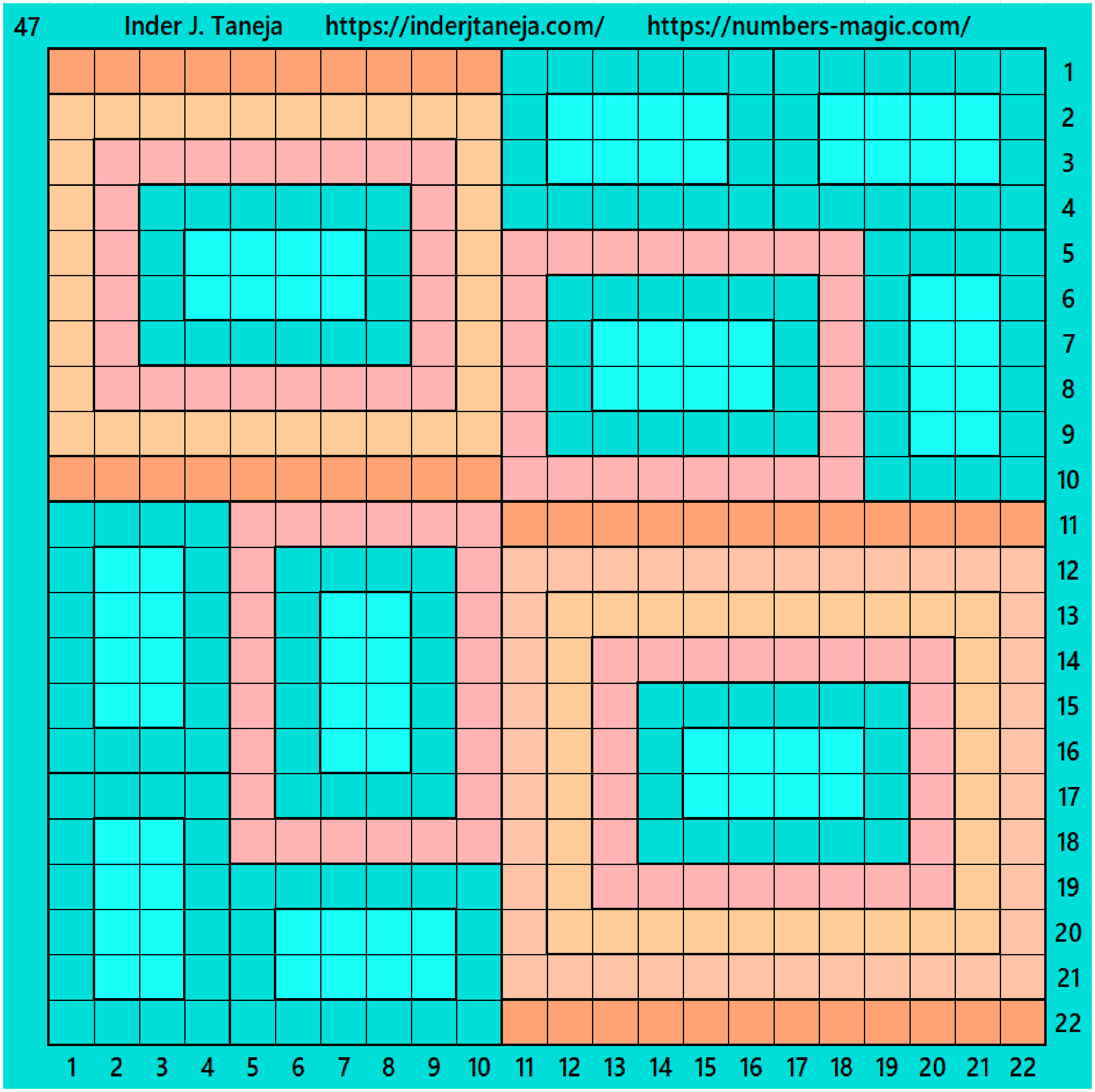
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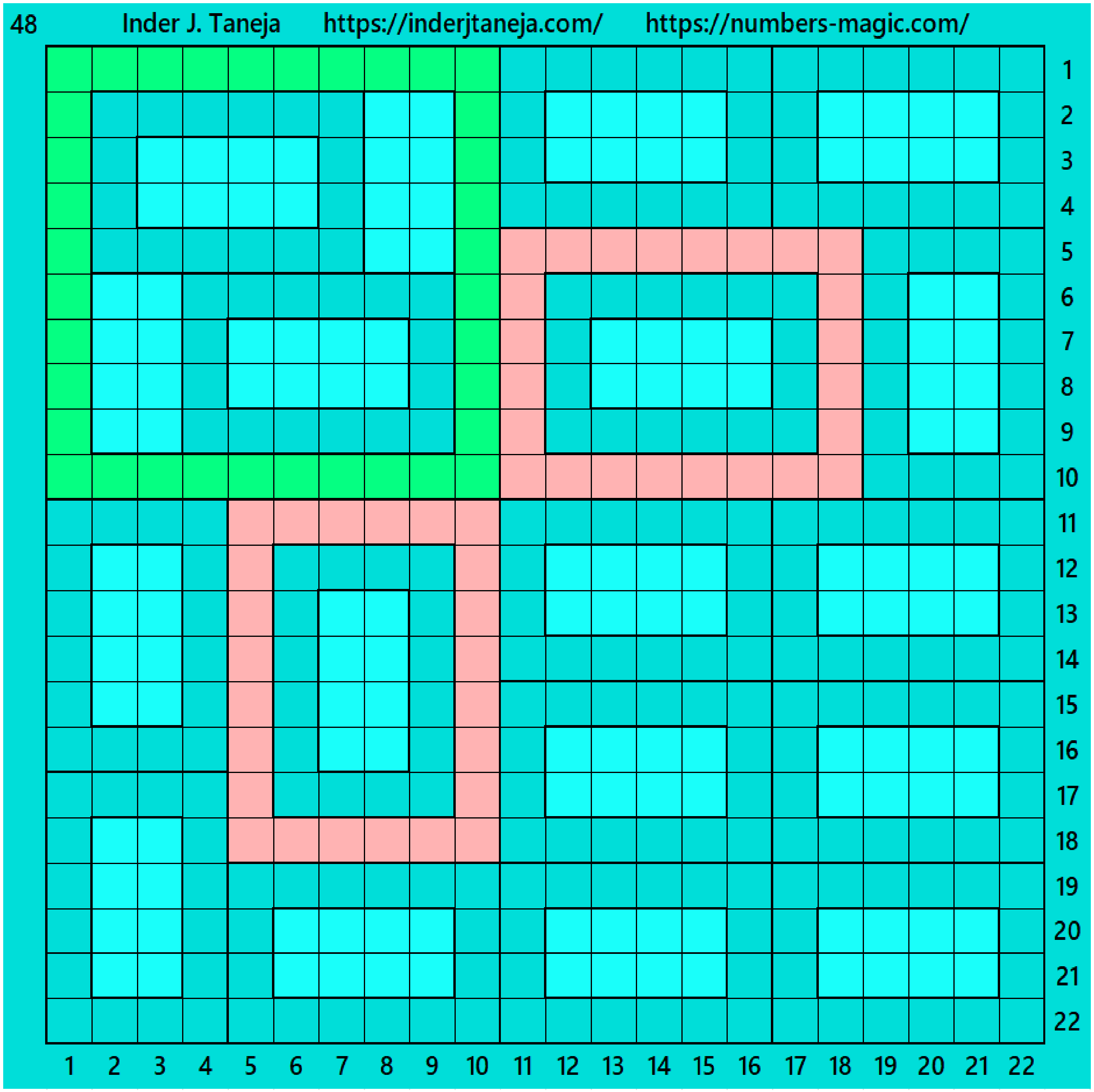
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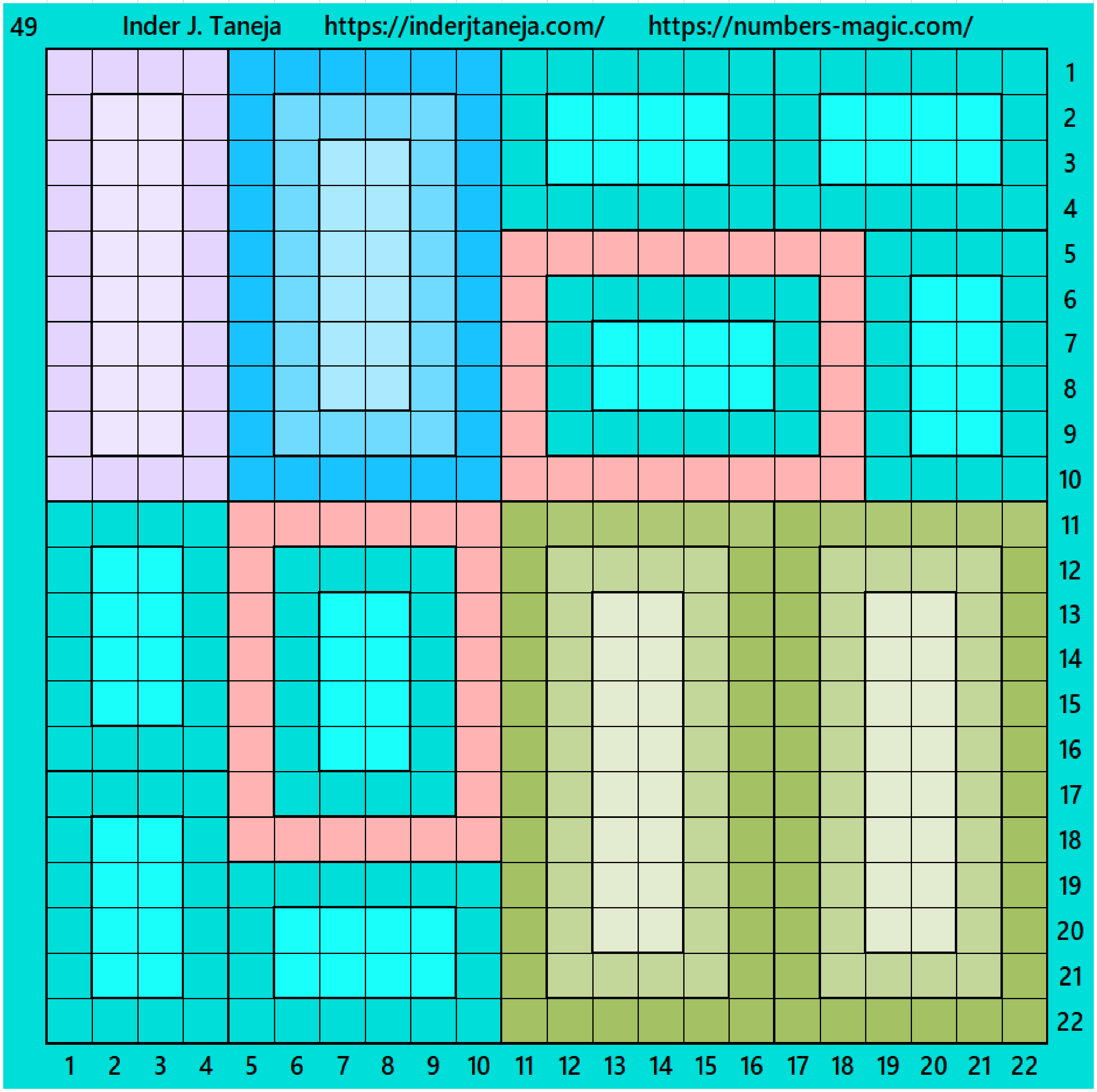

3 Appendix

Below are tables giving the existence of **bordered magic rectangles** for **half-sequential** numbers.

Order of Magic Square	Bordered Magic Rectangles
6	4×6
8	6×8
10	4×10, 8×10
12	6×12, 10×12
14	4×14, 8×14, 12×14
16	6×16, 10×16, 14×16
18	4×18, 8×18, 12×18
20	6×20, 10×20, 14×20, 18×20
22	4×22, 8×22, 12×22, 16×22, 20×22
24	6×24, 10×24, 14×24, 18×24, 22×24
26	4×26, 8×26, 12×26, 16×26, 20×26, 24×26
28	6×28, 10×28, 14×28, 18×28, 22×28, 26×28
30	4×30, 8×30, 12×30, 16×30, 20×30, 24×30, 28×30
32	6×32, 10×32, 14×32, 18×32, 22×32, 26×32, 30×32
34	4×34, 8×34, 12×34, 16×34, 20×34, 24×34, 28×34, 32×34

Order of Magic Square	Bordered Magic Rectangles
36	6×36, 10×36, 14×36, 18×36, 22×36, 26×36, 30×36, 34×36
38	4×38, 8×38, 12×38, 16×38, 20×38, 24×38, 28×38, 32×38, 36×38
40	6×40, 10×40, 14×40, 18×40, 22×40, 26×40, 30×40, 34×40, 38×40
42	4×42, 8×42, 12×42, 16×42, 20×42, 24×42, 28×42, 32×42, 36×42, 40×42
44	6×44, 10×44, 14×44, 18×44, 22×44, 26×44, 30×44, 34×44, 38×44,42×44
46	4×46, 8×46, 12×46, 16×46, 20×46, 24×46, 28×46, 32×46, 36×46, 40×46, 44×46
48	6×48, 10×48, 14×48, 18×48, 22×48, 26×48, 30×48, 34×48, 38×48, 42×48, 46×48
50	4×50, 8×50, 12×50, 16×50, 20×50, 24×50, 28×50, 32×50, 36×50, 40×50, 44×50, 48×50

4 Author's Contribution to Magic Squares and Recreation Numbers

For author's contribution to **magic squares** and **recreation numbers** please see the links below:

- **Inder J. Taneja**, Magic Squares, *https://inderjtaneja.com/2019/06/27/publications-magic-squares/*
- **Inder J. Taneja**, Recreation of Numbers, *https://inderjtaneja.com/2019/06/27/publications-recreation-of-numbers/*

Acknowledgement

The **bordered magic rectangles** are constructed based on the software produced by H. White [1]. The author is thankful to H. White for his valuable help.

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- **Block-Wise Magic Squares**

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