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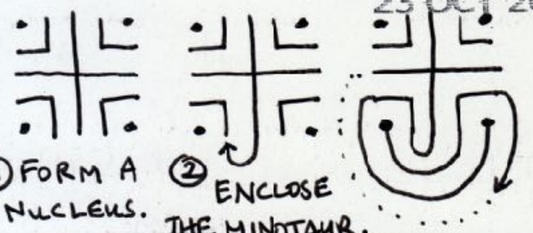
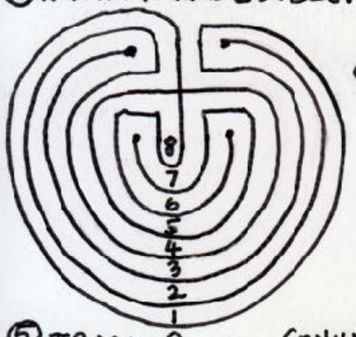
HOW TO DRAW & COUNT LABYRINTHS

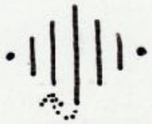


① FORM A NUCLEUS. ② ENCLOSE THE MINOTAUR. ③ CAP OFF END POINTS.

④ NUMBER THE LEVELS.



CONUNDRUM I. DRAW & COUNT THE DIAMOND LABYRINTH



⑤ TRACE THE PATH FOR ~~Robert Smithson~~ THESEUS: 032147658. 0543216.

CONUNDRUM II. DRAW THE LABYRINTH WITH THESEUS PATH

Spiral Jetty, 1970, Great Salt Lake, Utah. Collection Dia Art Foundation. Photo © George Steinmetz.
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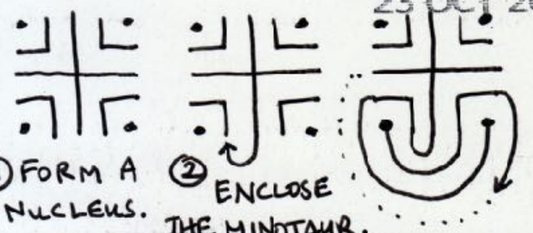
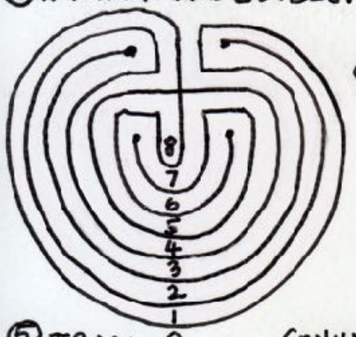
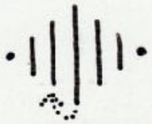


① FORM A NUCLEUS. ② ENCLOSE THE MINOTAUR. ③ CAP OFF END POINTS.

④ NUMBER THE LEVELS.



CONUNDRUM I. DRAW & COUNT THE DIAMOND LABYRINTH



⑤ TRACE THE PATH FOR ~~Robert Smithson~~ THESEUS: 032147658. 0543216.

CONUNDRUM II. DRAW THE LABYRINTH WITH THESEUS PATH

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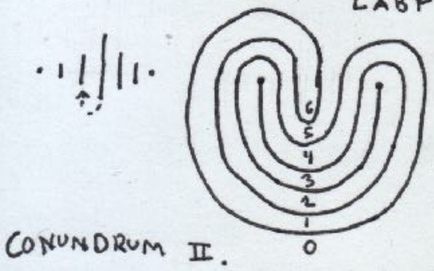
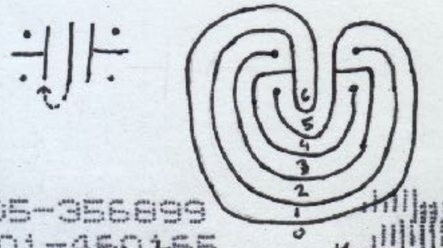
CONUNDRUM I. DIAMOND LABYRINTH



THESEUS PATH: 0523416

CONUNDRUM II.

LABYRINTH WITH THESEUS PATH 0543216



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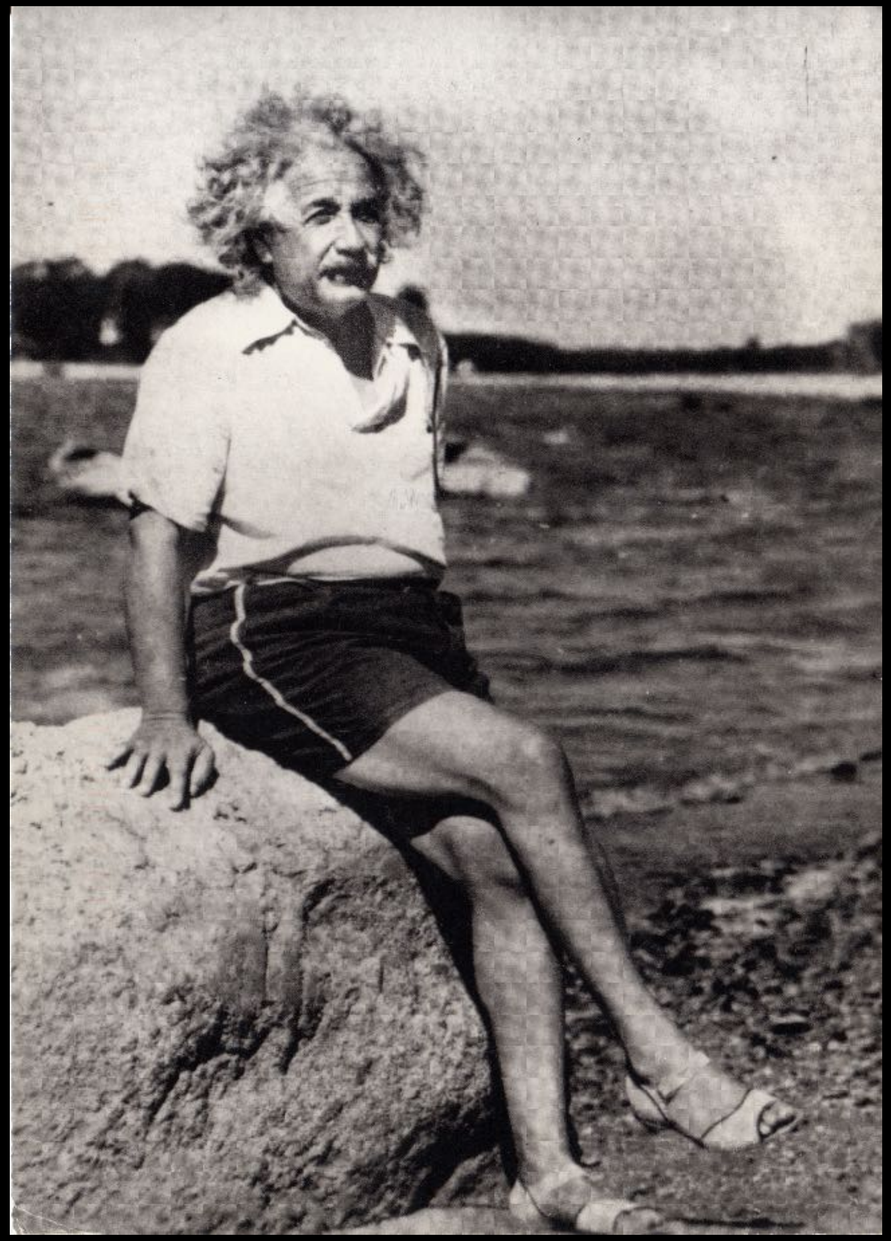

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ALBERT EINSTEIN, c.1945 (AKA "MINOTAUR LIBERATOR")
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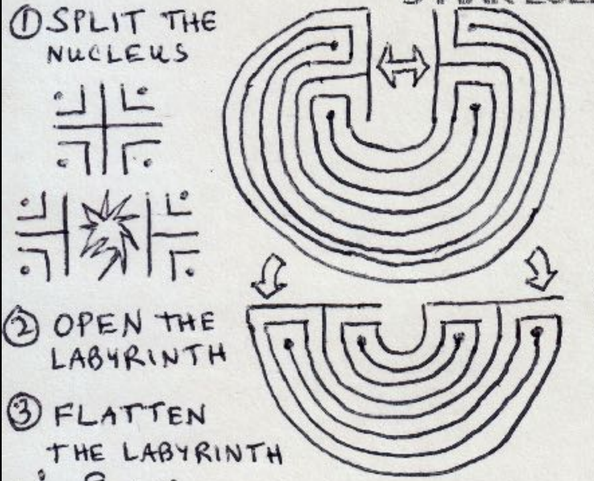
HOW TO UNROLL A LABYRINTH

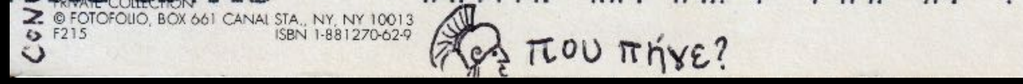
① SPLIT THE NUCLEUS



② OPEN THE LABYRINTH

③ FLATTEN THE LABYRINTH

CONUNDRUM III.
UNROLL THE DIAMOND
R0543216
LABYRINTHS



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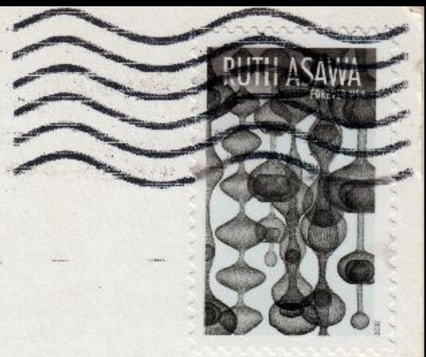

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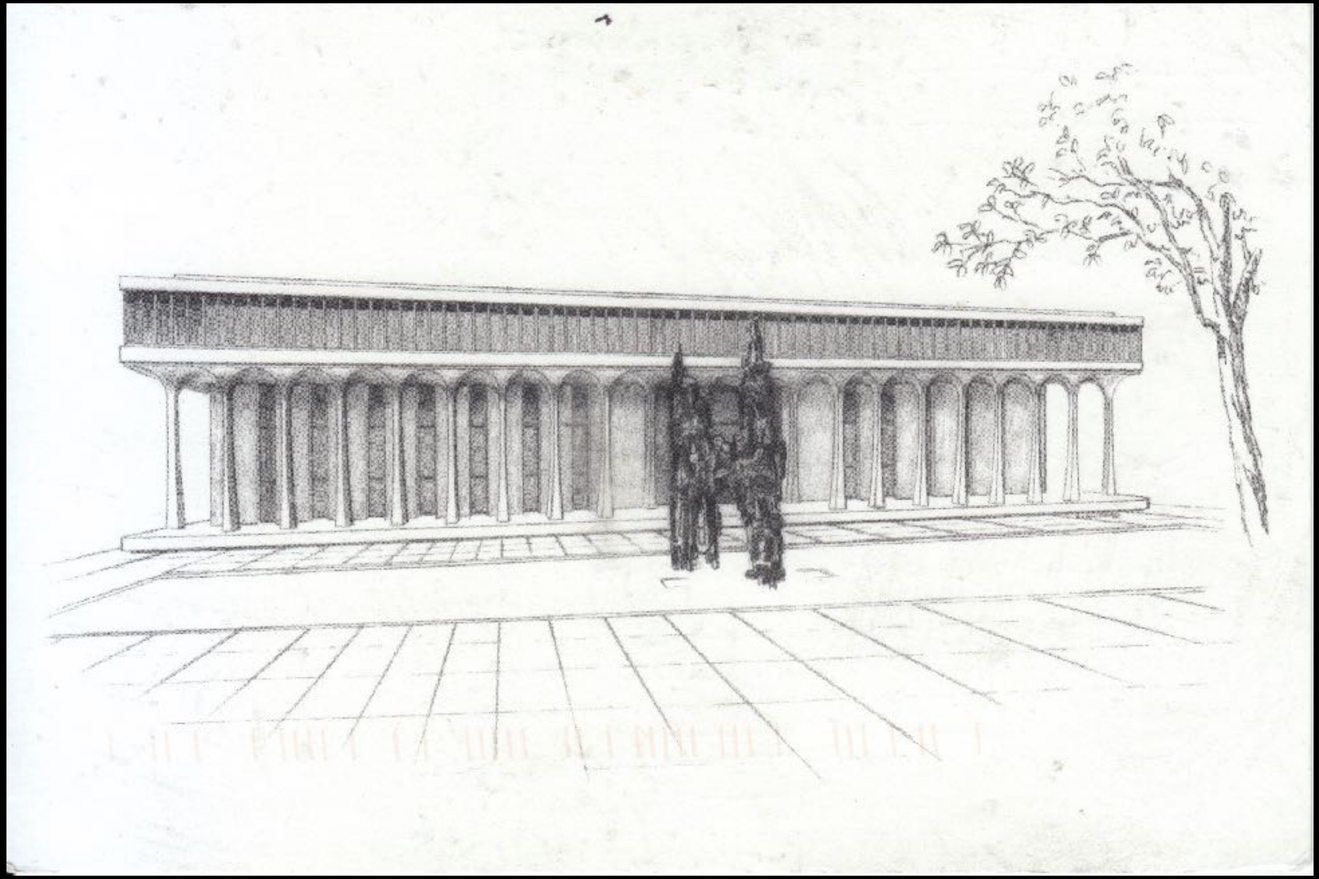

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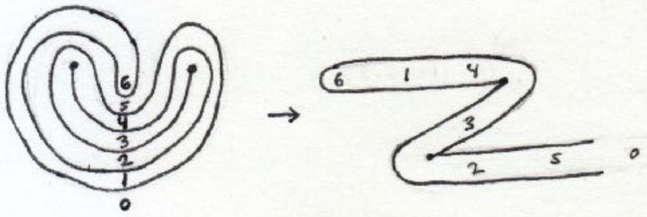
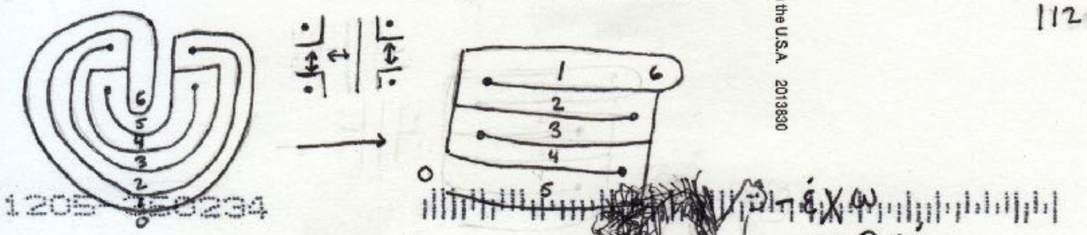
CONUNDRUM III.

A. UNROLL THE DIAMOND LABYRINTH



B. UNROLL THE 0543216 LABYRINTH



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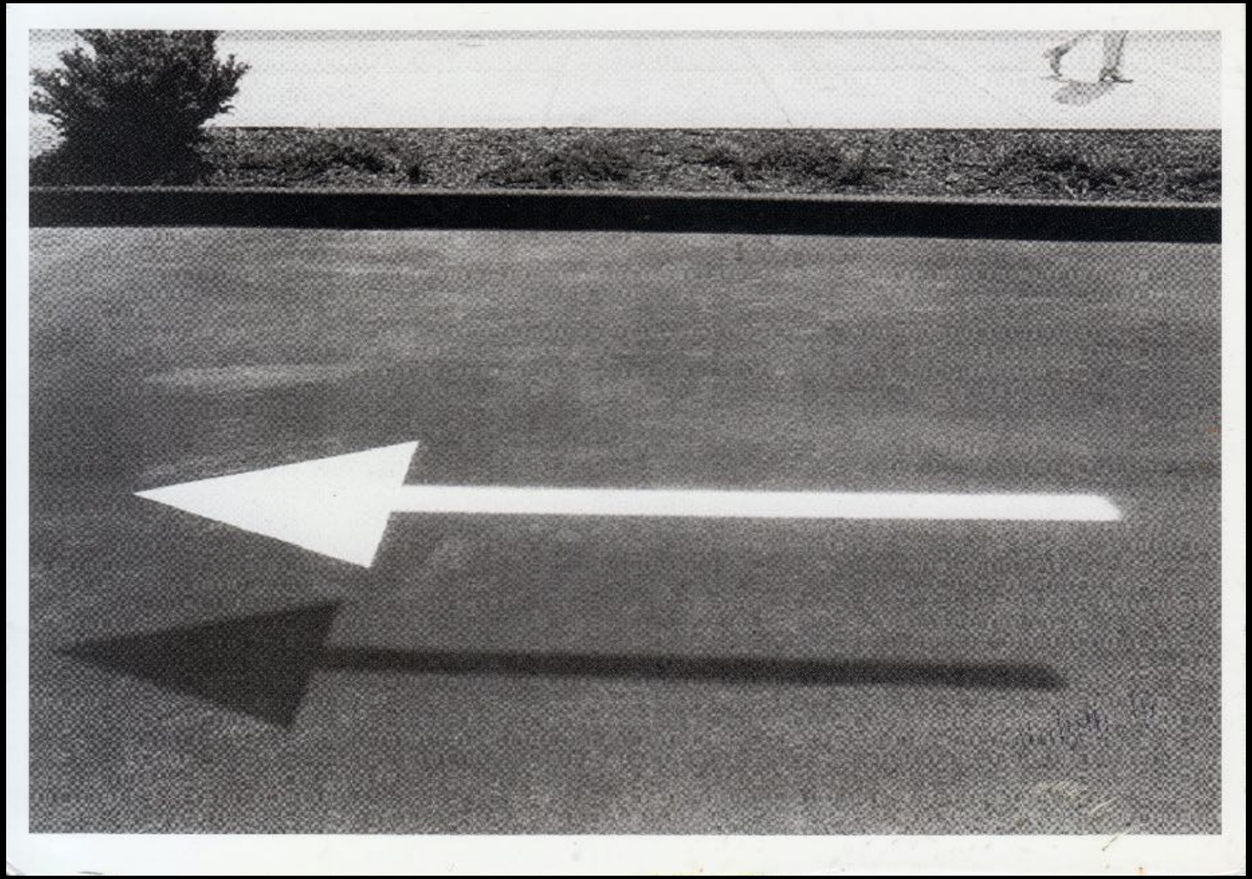

UNTITLED, 1983. PHOTOGRAPH BY © KARL BADEN <<5T&5

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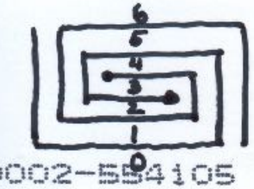
HOW TO MULTIPLY A LABYRINTH

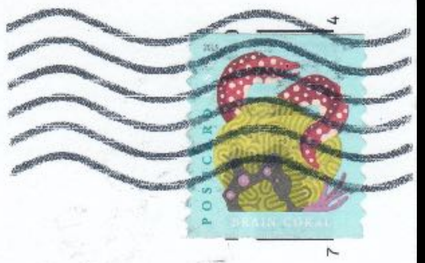
① UNROLL IT ② DUPLICATE ③ CONNECT

CONUNDRUM IV. DRAW AND COUNT THE LITTLE CRETAN LABYRINTH W/ NUCLEUS THEN MULTIPLY IT



CONUNDRUM V. MULTIPLY THE 0543216 LABYRINTH

TIP: KEEP THE LEVELS IN ORDER THRU-OUT UNROLLING



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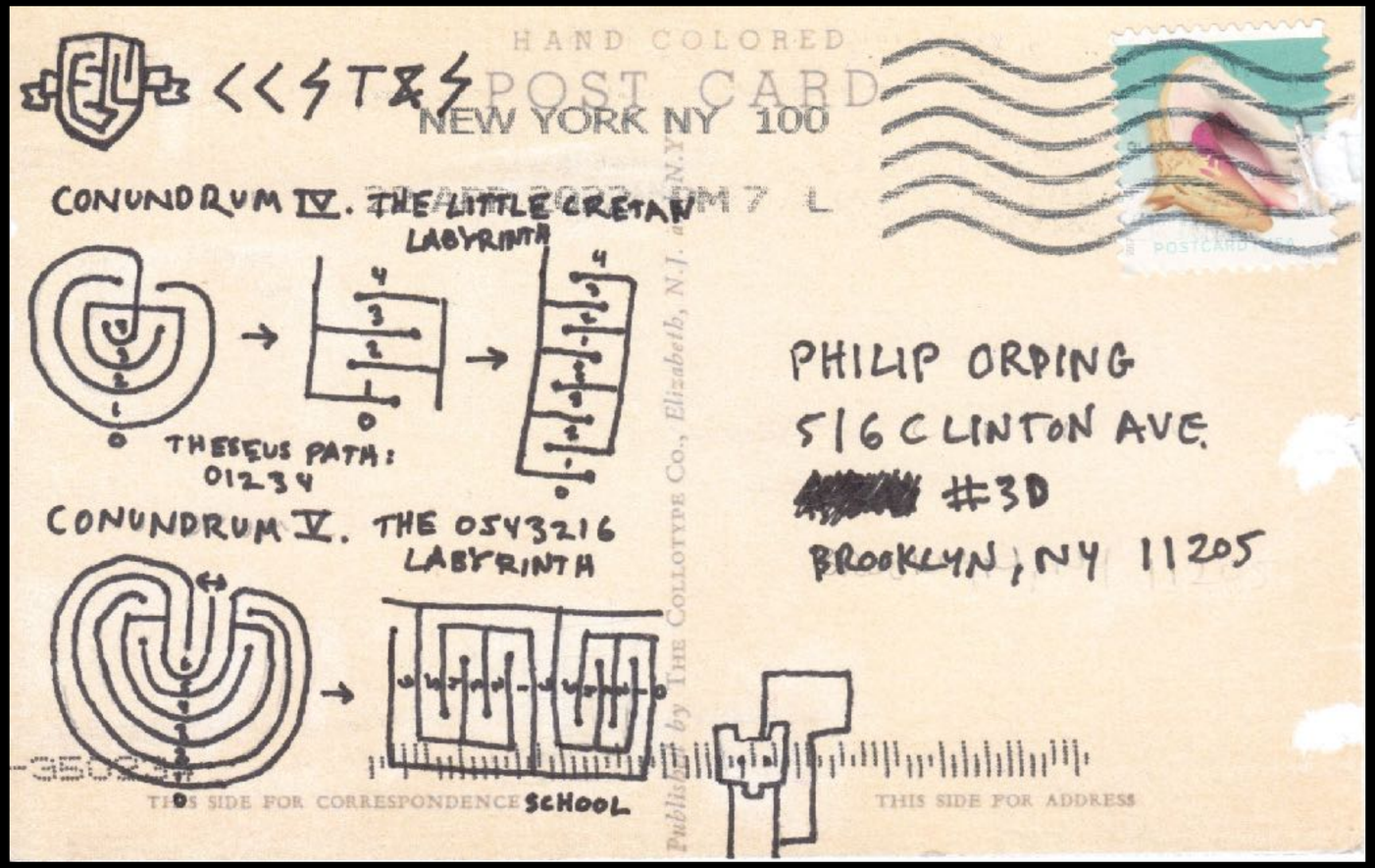
Look who's in stern. Good trip F.a.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CONUNDRUM IV. THE LITTLE CRETAN LABYRINTH
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CONUNDRUM V. THE 0543216 LABYRINTH
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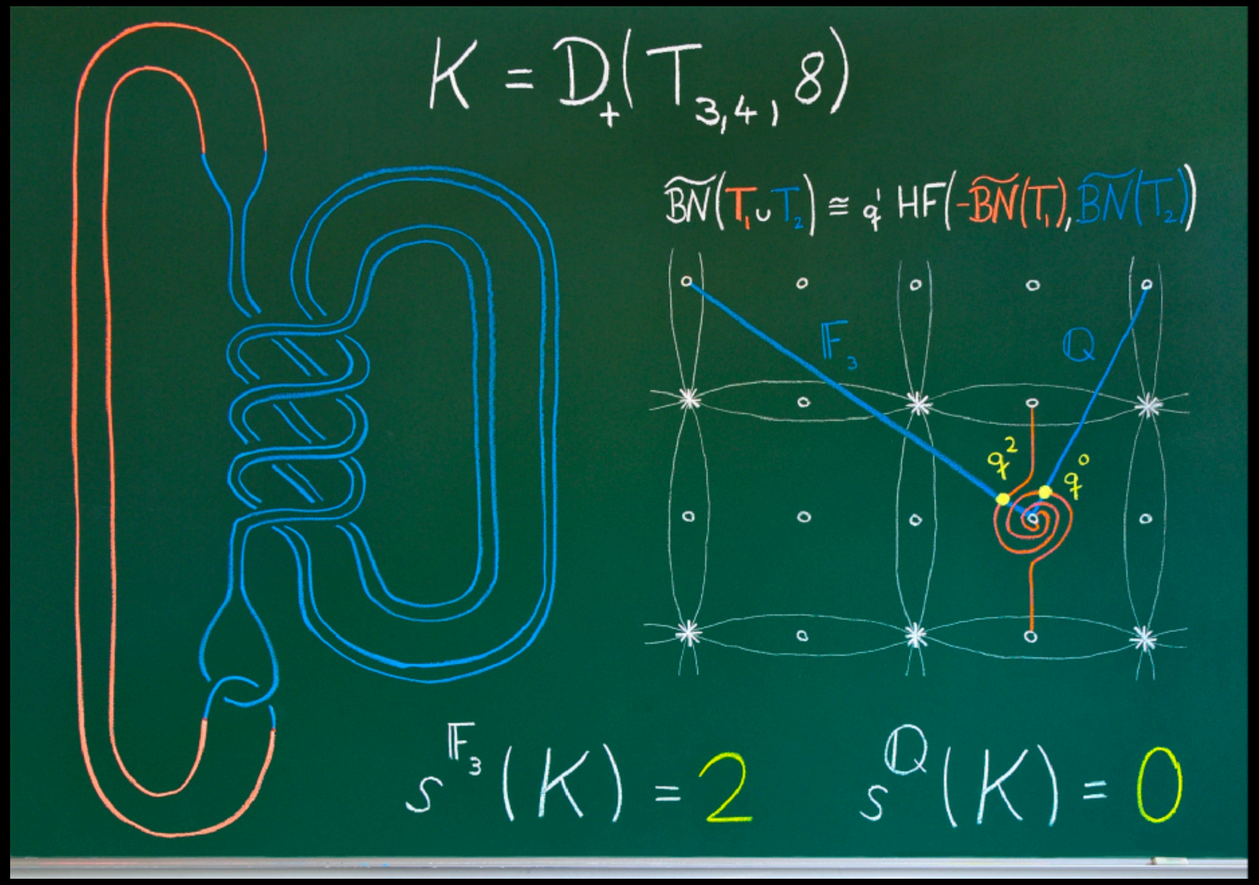

Symmetry & Mutation

Liam Watson
University of British Columbia, Department of Mathematics
liam@math.ubc.ca

April 28, 2021. When Conway set about tabulating knots in the 1960s, appealing to a divide-and-conquer method involving tangles, he came up against an interesting ambiguity when certain tangles are reassembled [2]. This became known as mutation—the result of removing a tangle, rotating it about an axis, and replacing it—and while it can alter the given knot, detecting the difference can be extremely subtle. Indeed, the original example led to a pair of knots later separated by Riley, appealing to representations of the knot group [5].

In general, mutation is invisible to a long list of knot invariants, some of which are remarkably powerful; on the other hand the question *what invariants see mutation?* is a tricky one. At least among prime knots, owing to a celebrated result of Gordon and Luecke [3], the knot group will always separate distinct mutants, but this goes from one hard problem to another; deciding if two groups are different is not easy. While anachronistic, Riley made use of this strength of the knot group by appealing to a robust invariant of groups in order to separate Conway's mutants.

Another example is shown on the front of the card. In this case a refinement of Khovanov homology taking a strong inversion into account is able to establish that the mutants are distinct [4]. A strong inversion is a type of involution and can be viewed as an element of the symmetry group of a knot; see [6]. This latter is the group of diffeomorphisms of the knot complement, up to isotopy. In this case, it turns out that the symmetry group itself separates the two mutants: one has symmetry group $\mathbb{Z}/2 \oplus \mathbb{Z}/2$ (a 4-element group) while the the other has dihedral symmetry group D_4 (an 8-element group).

For the smaller of the two groups, a generating set has been shown on the front of the card. For the larger group, the order 4 element is obtained by composing a flype with a rotation; see Boyle [1].

In the end a principle similar to that applied by Riley is in play: The symmetry group of a hyperbolic knot agrees with the outer-automorphism group of the knot group. On the other hand, I was surprised to see this work, in practice, on such a simple example. And it seems worth recording:

Theorem. *Mutants that are separated by the symmetry group exist.*

Moreover, this example shows that the symmetry group does the job even in cases where neither knot Floer homology nor Khovanov homology is able to make the distinction.

[1] Boyle. Involutions of alternating links. *Proc. Amer. Math. Soc.*, to appear.
[2] Conway. An enumeration of knots and links. In *Computational Problems in Abstract Algebra*, 1970.
[3] Gordon & Luecke. Knots are determined by their complements. *J. Amer. Math. Soc.*, 1989.
[4] Lobb & Watson. A refinement of Khovanov homology. *Geom. Topol.*, to appear.
[5] Riley. Homomorphisms of knot groups on finite groups. *Math. Comp.*, 1971.
[6] Sakuma. On strongly invertible knots. In *Algebraic and topological theories*, 1986.

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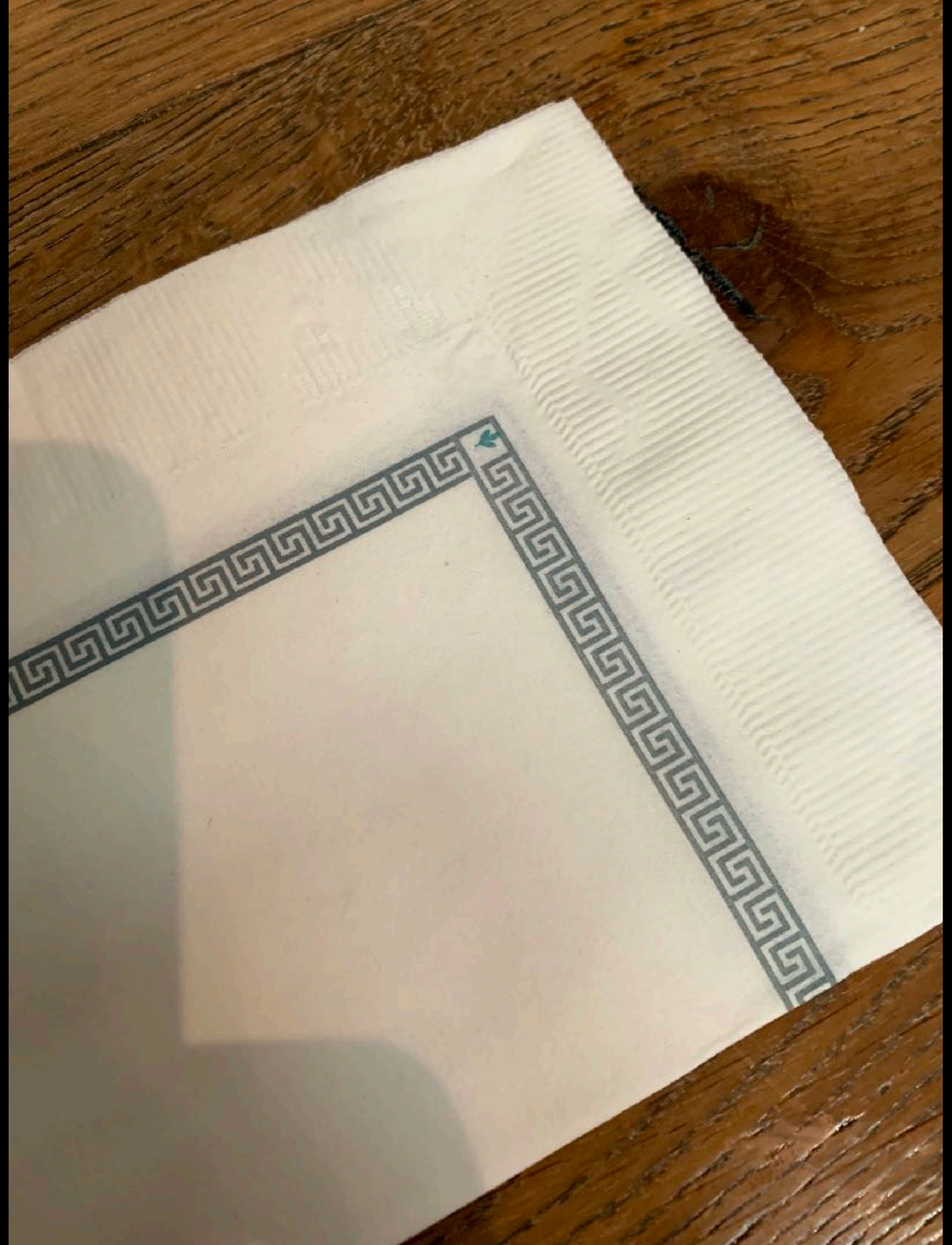

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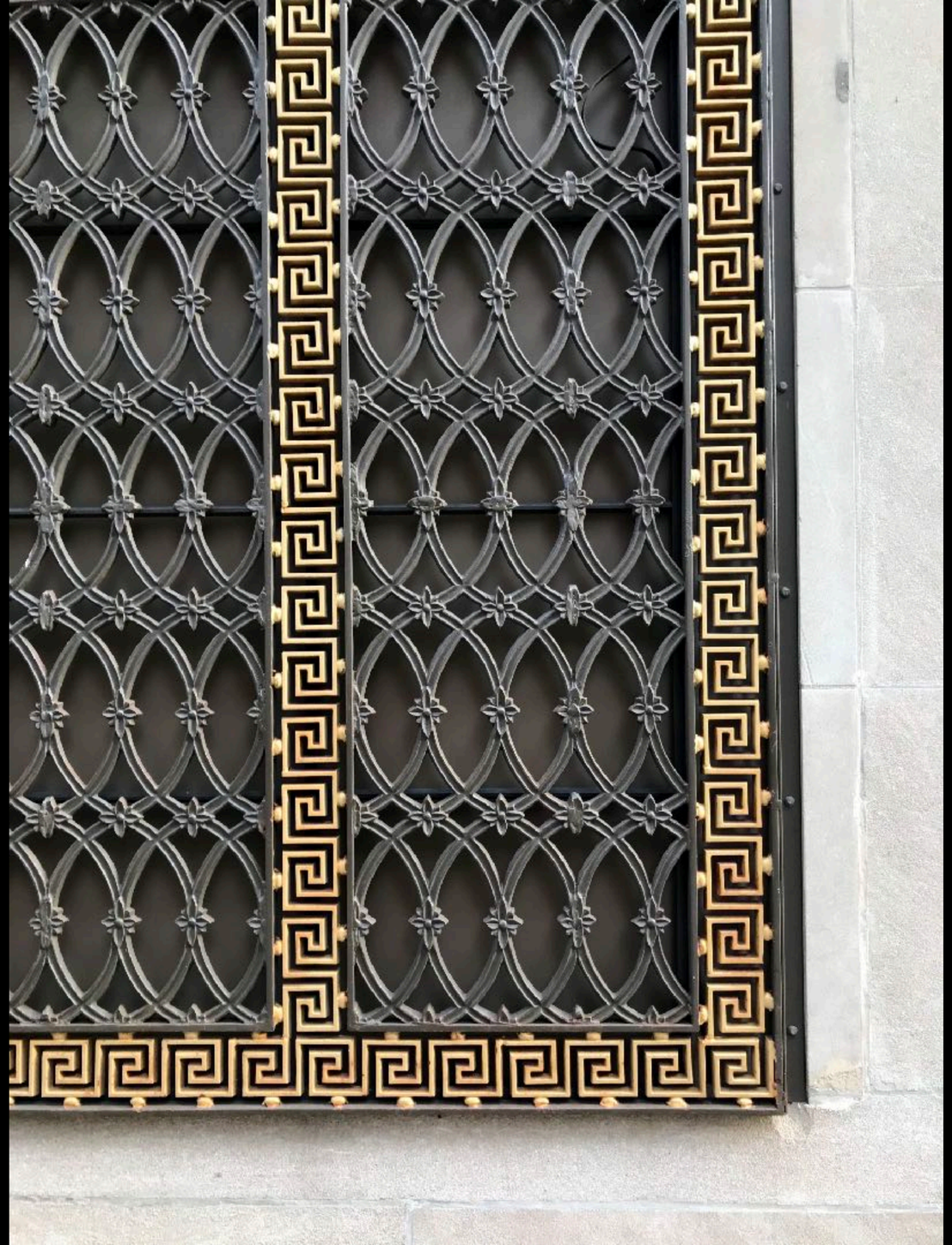

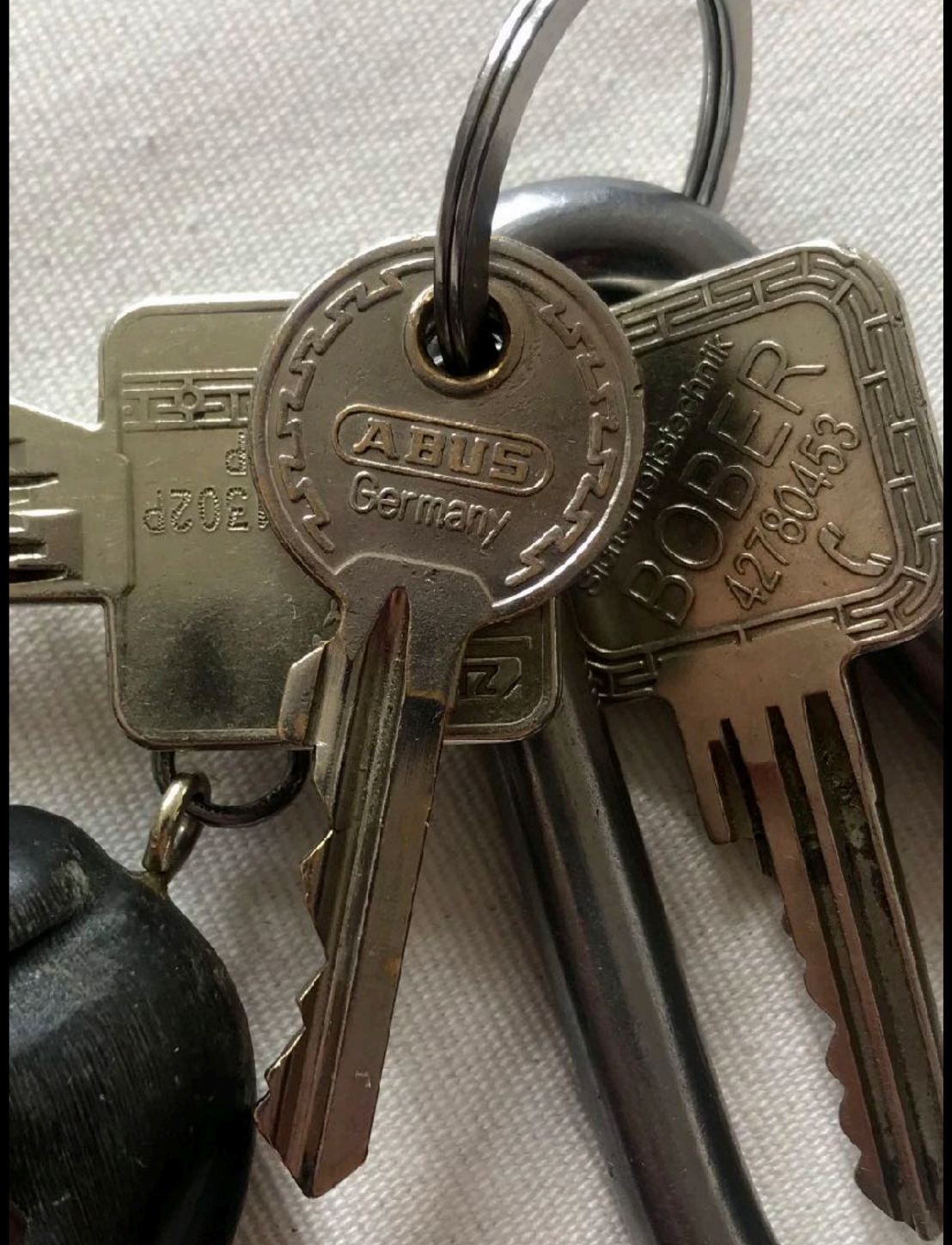
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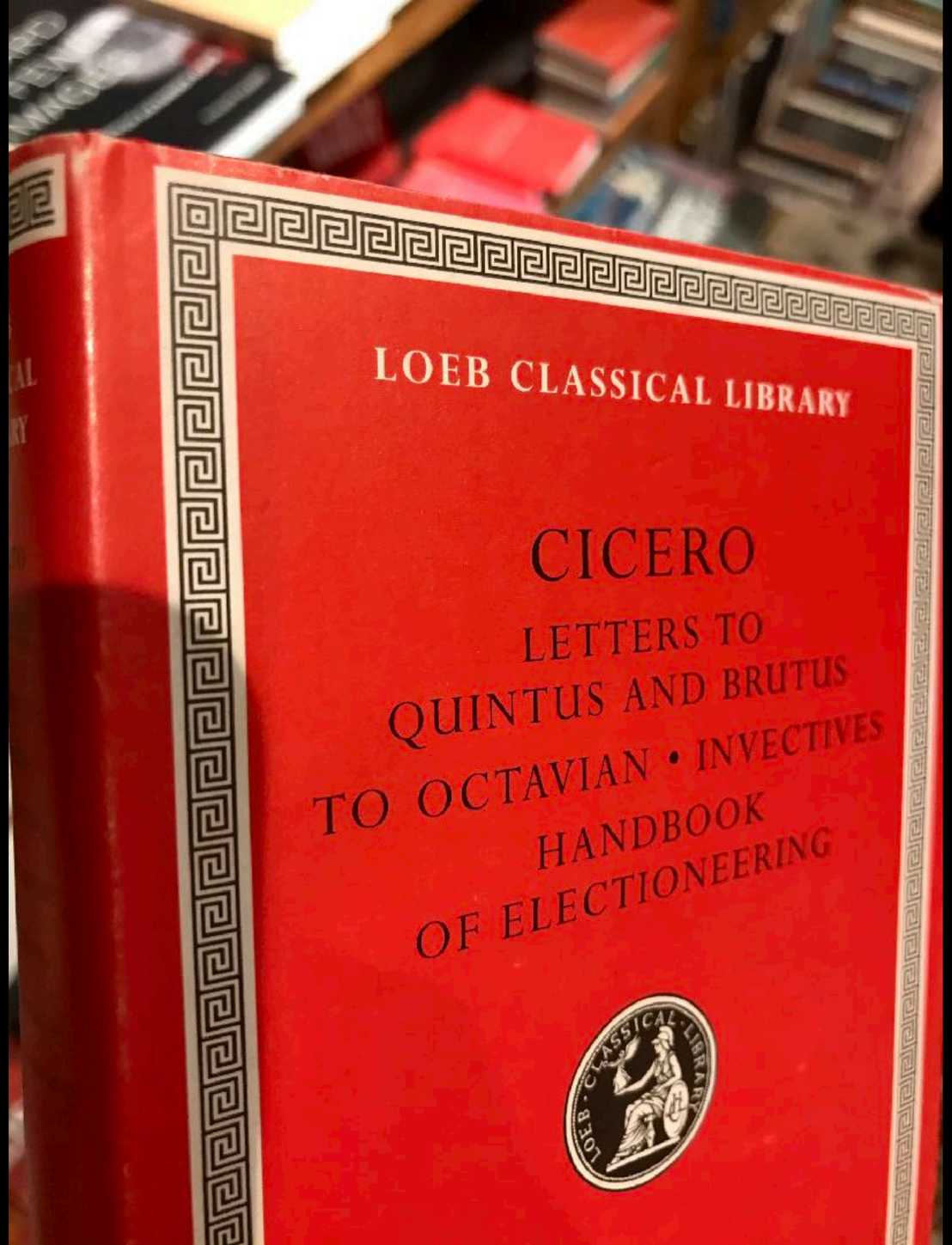
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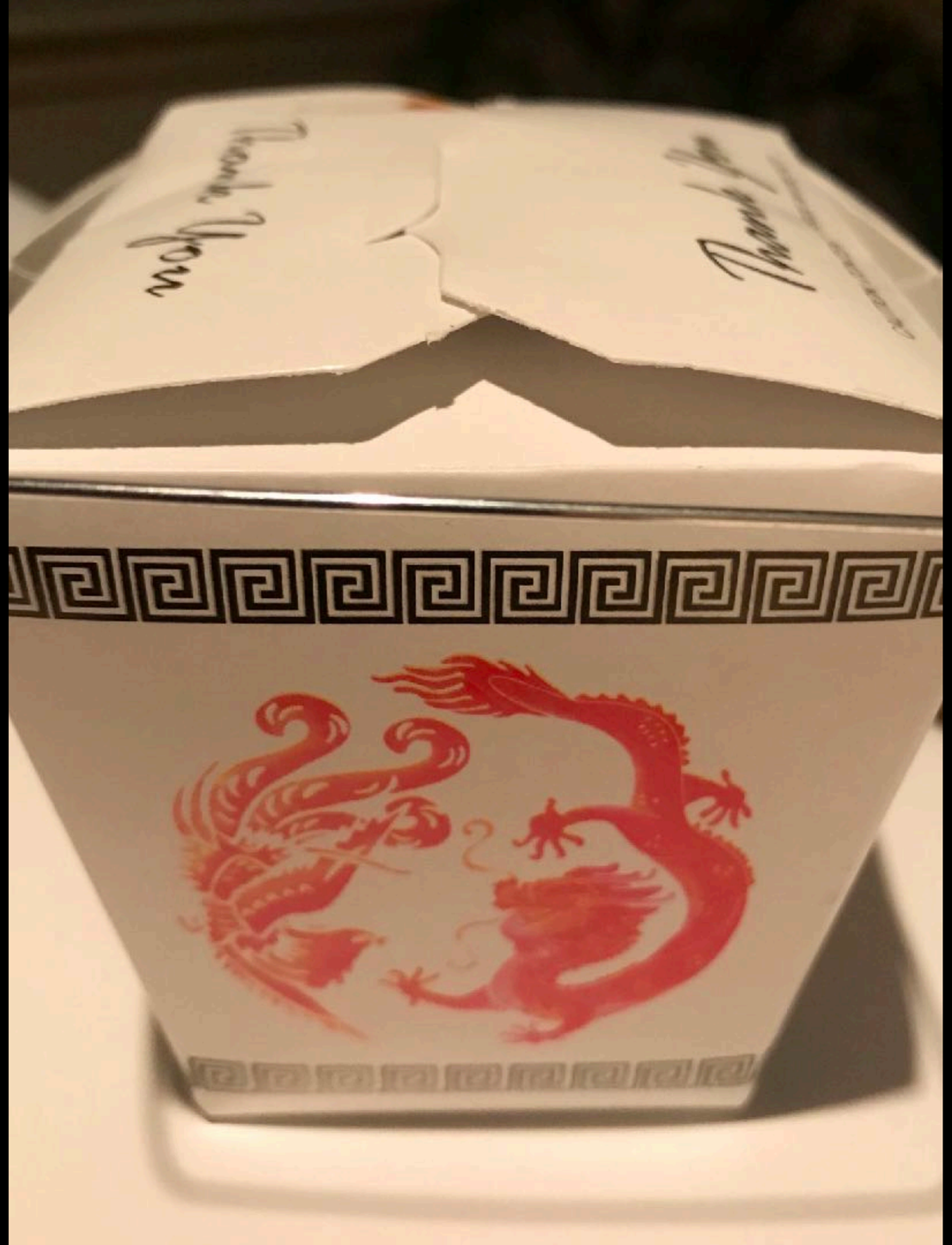

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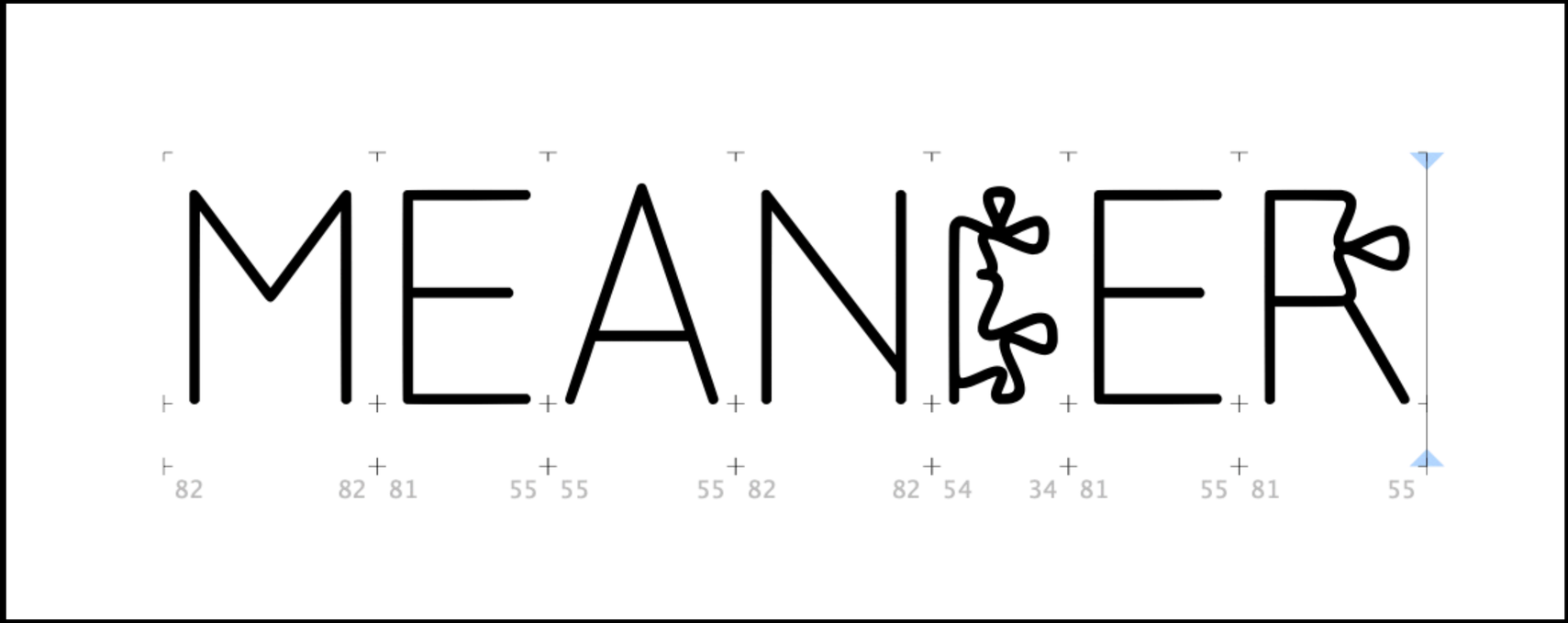
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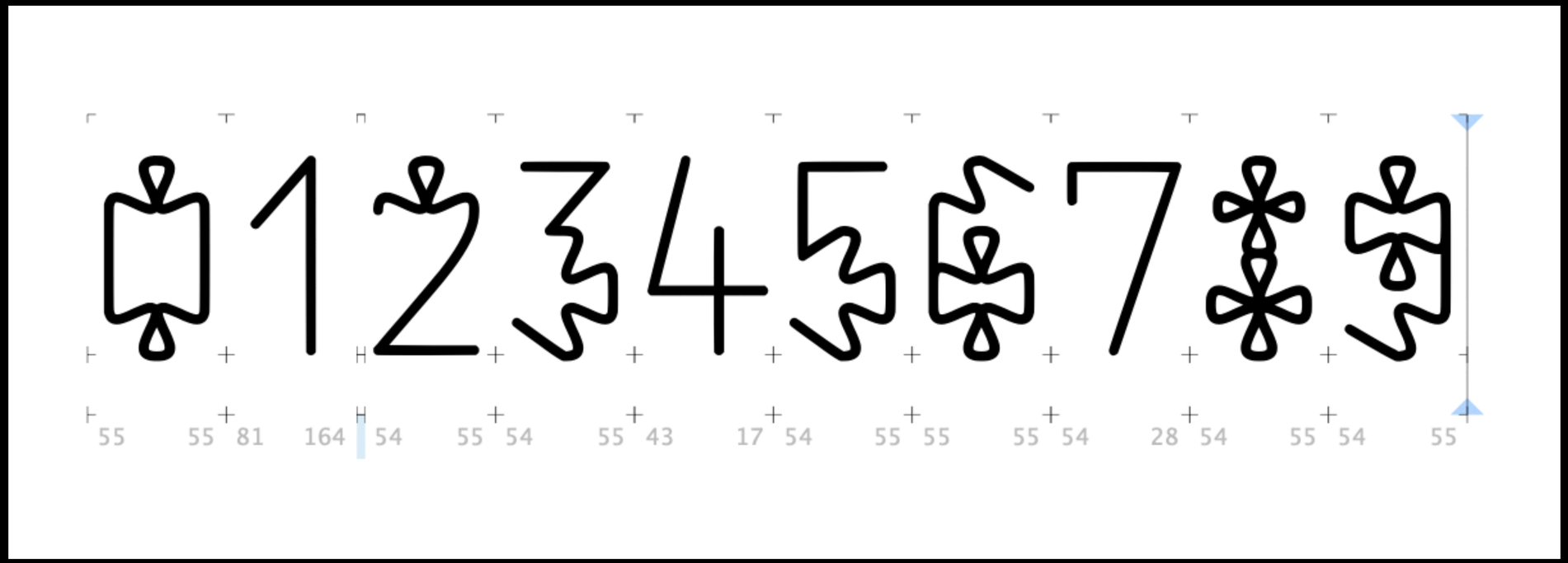
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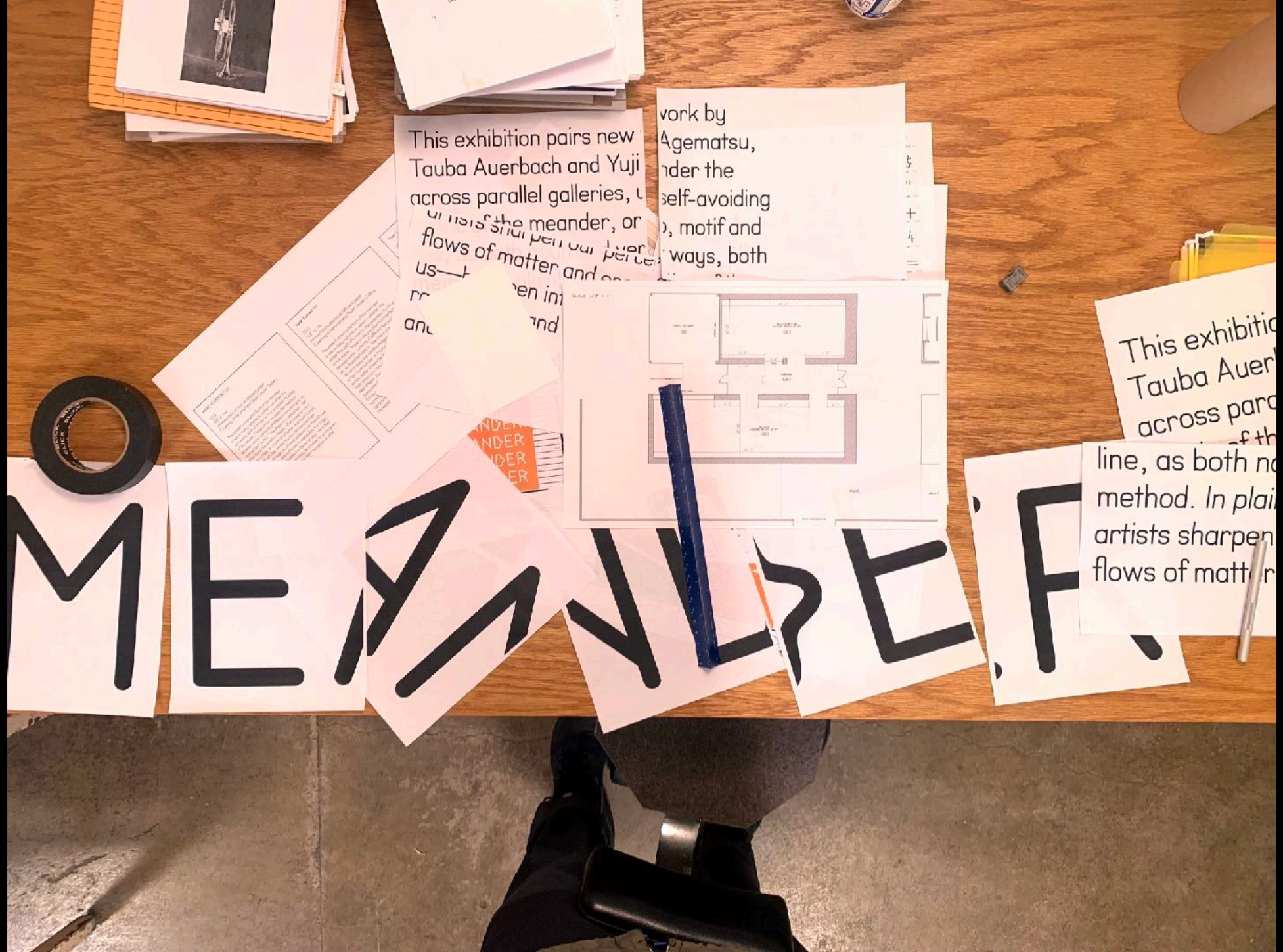
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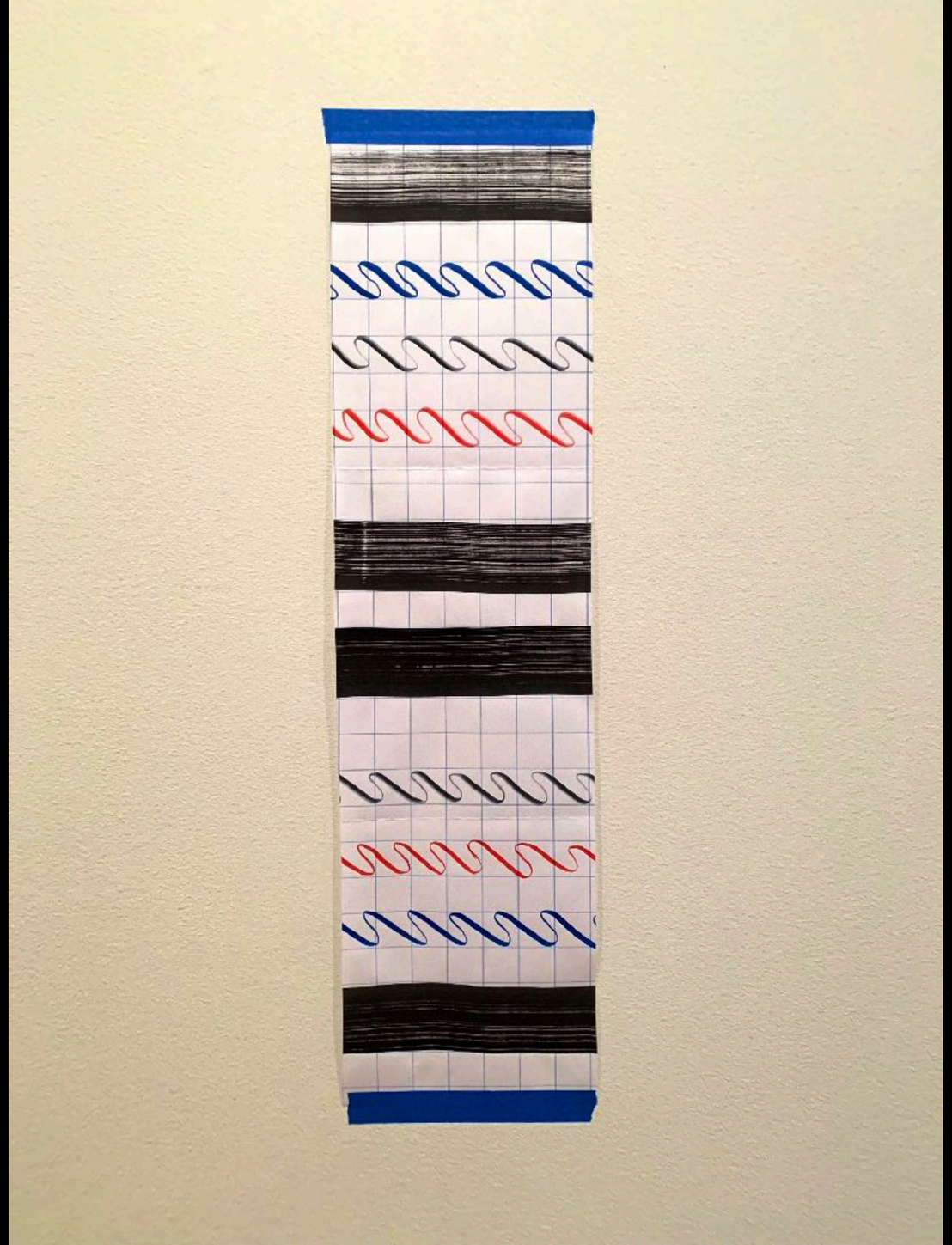

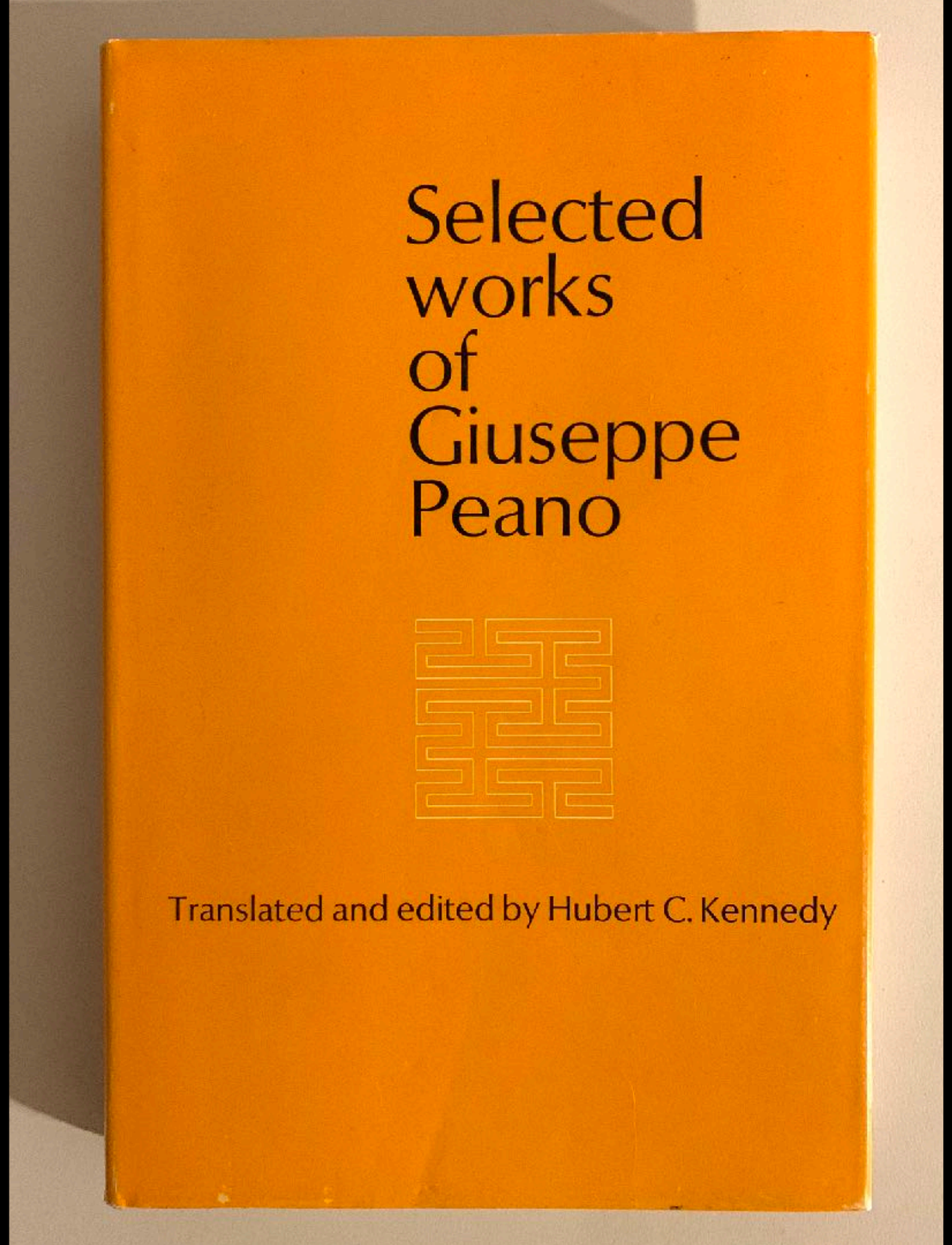
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Translated and edited by Hubert C. Kennedy

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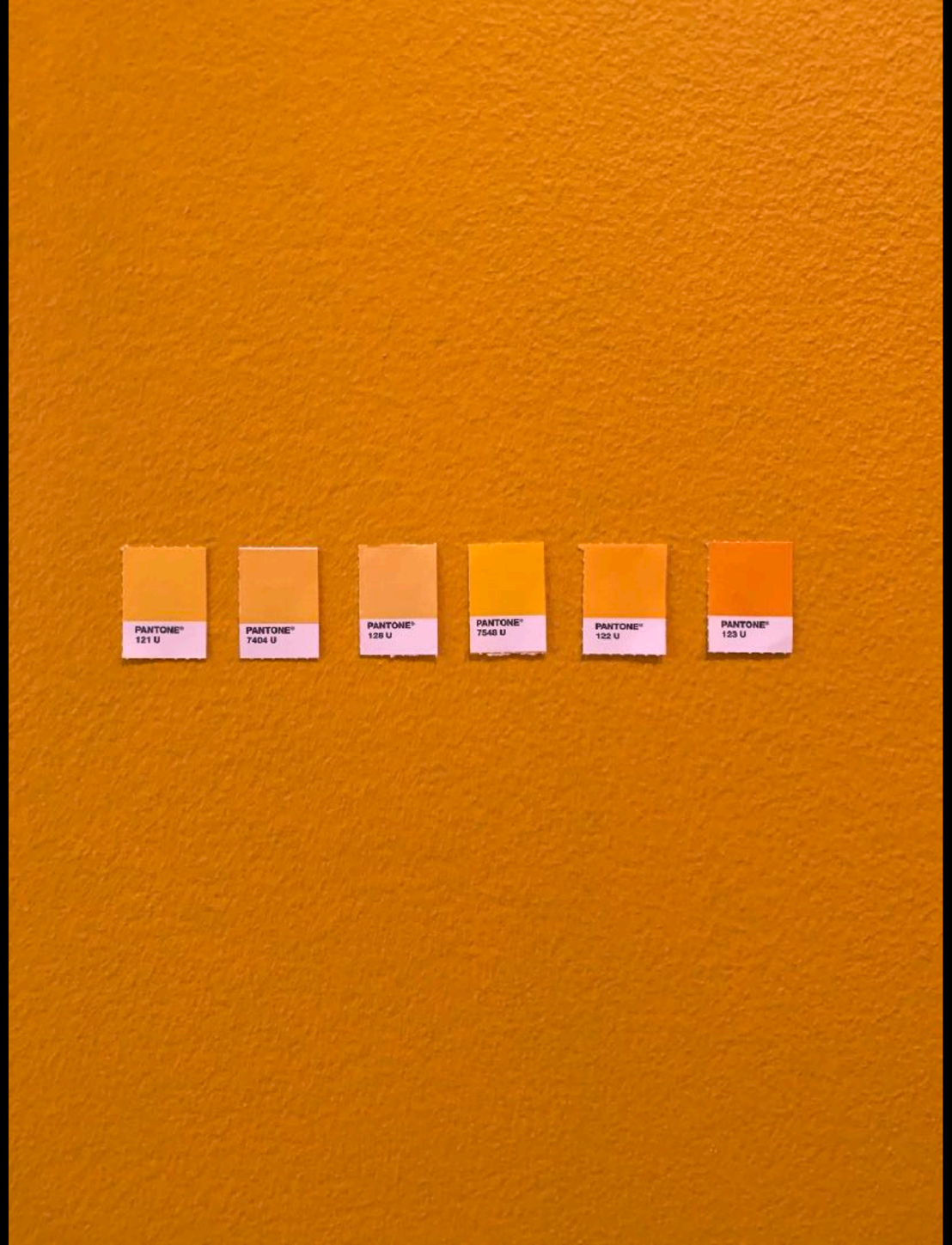
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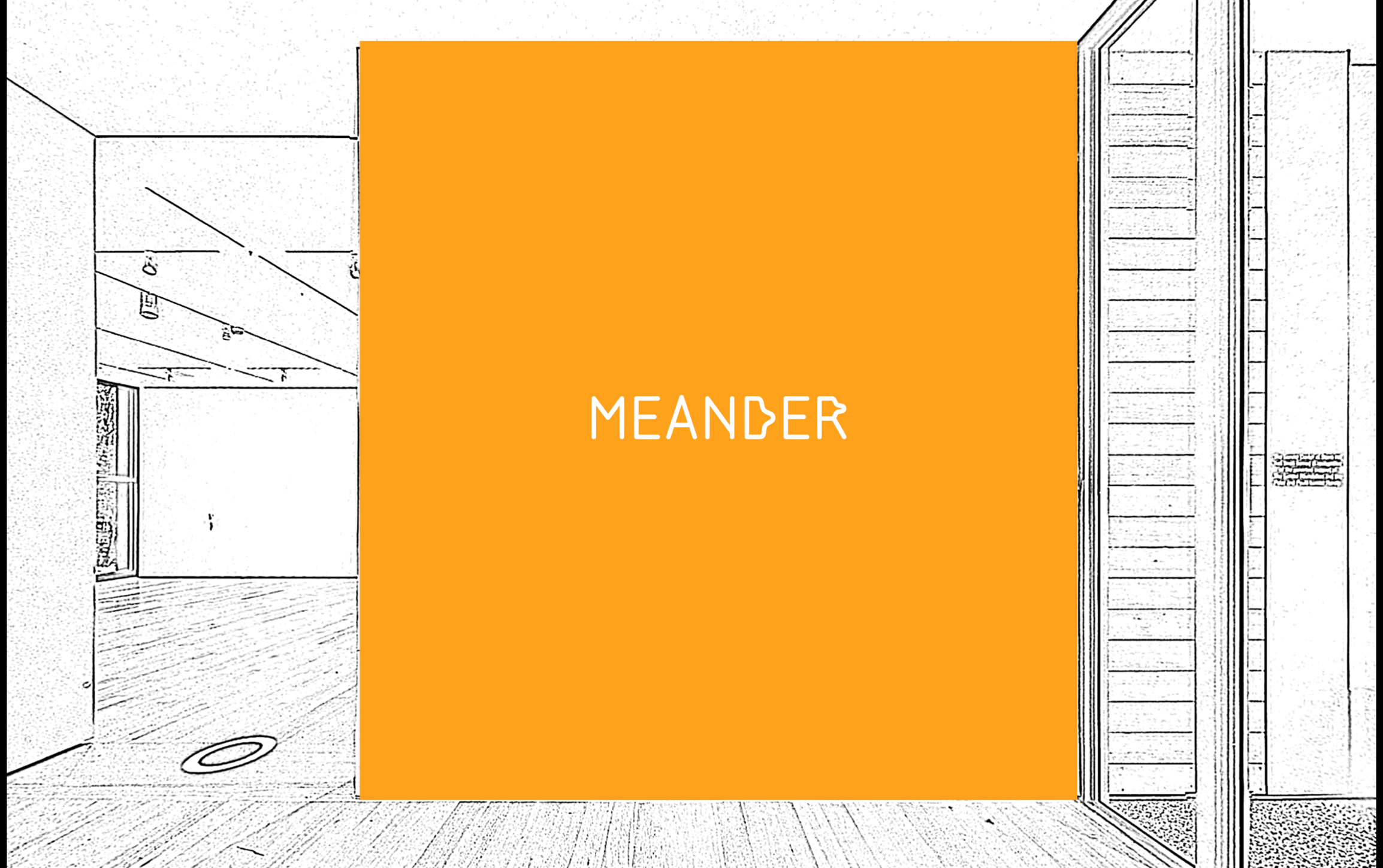

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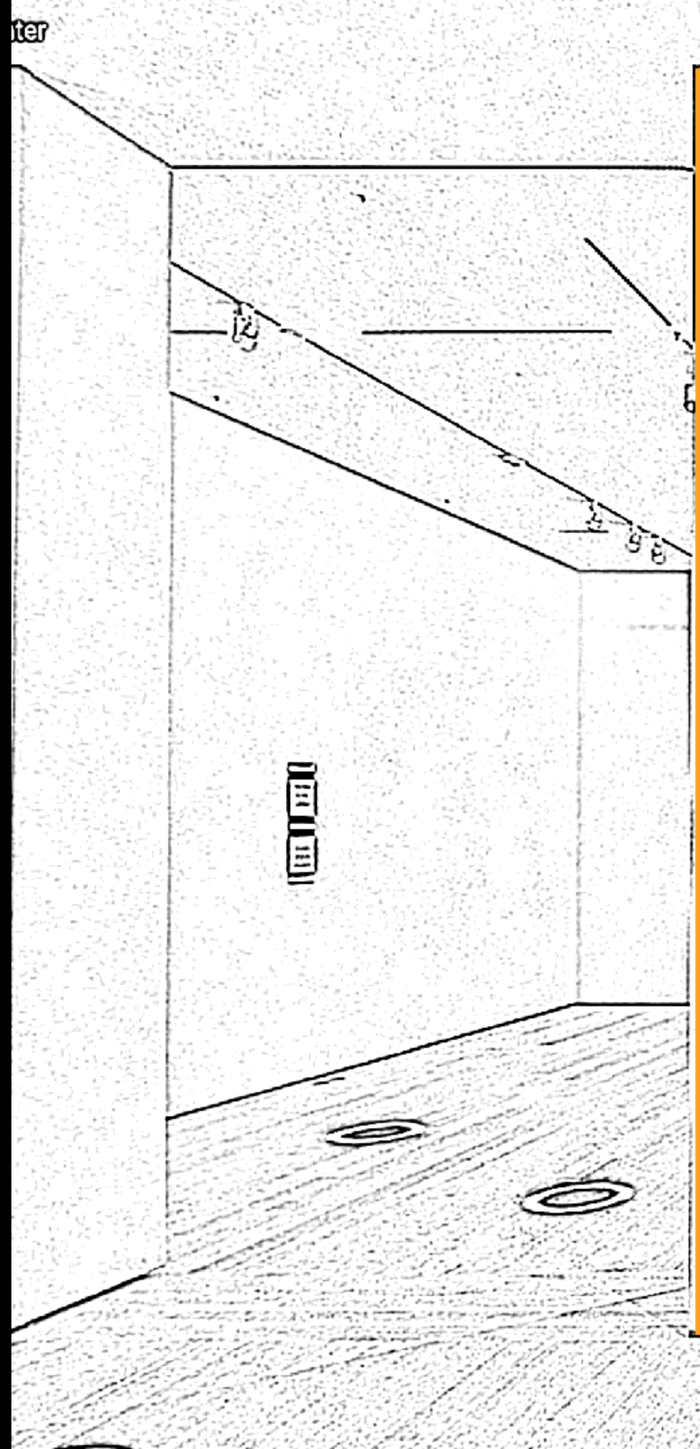

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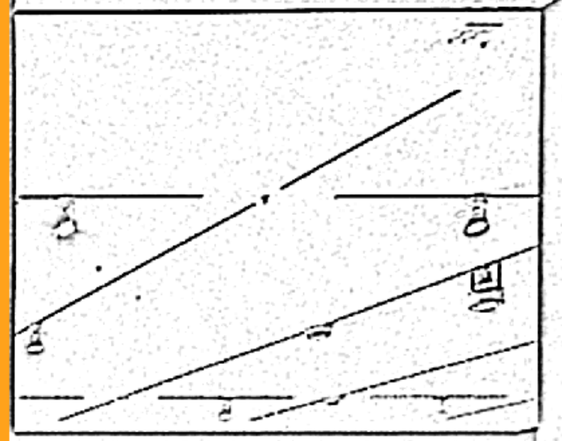

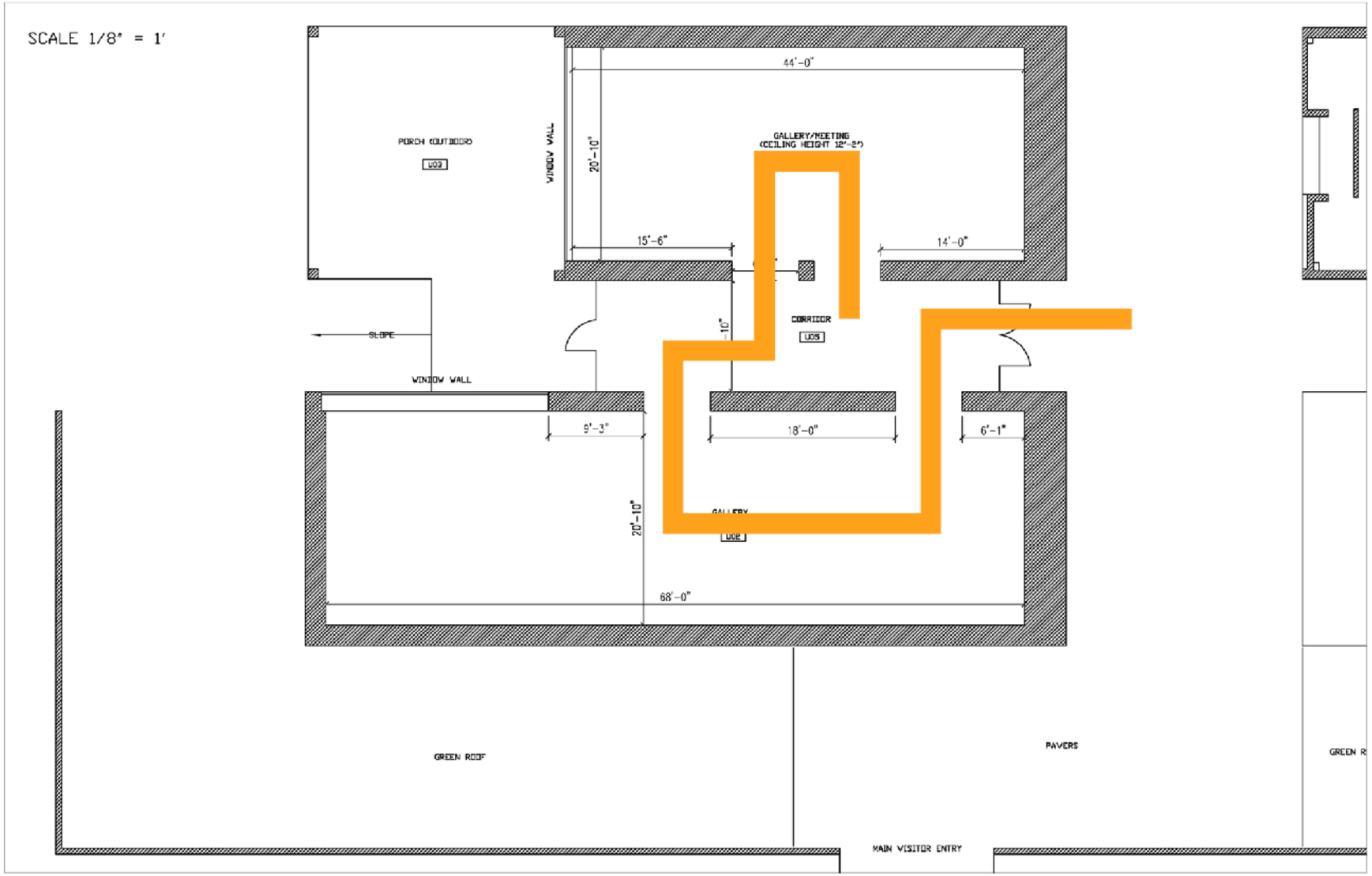
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15'-6"
14'-0"
10"
CORRIDOR
U05
SLOPE
WINDOW WALL
9'-3"
18'-0"
6'-1"
20'-10"
GALLERY
U02
68'-0"
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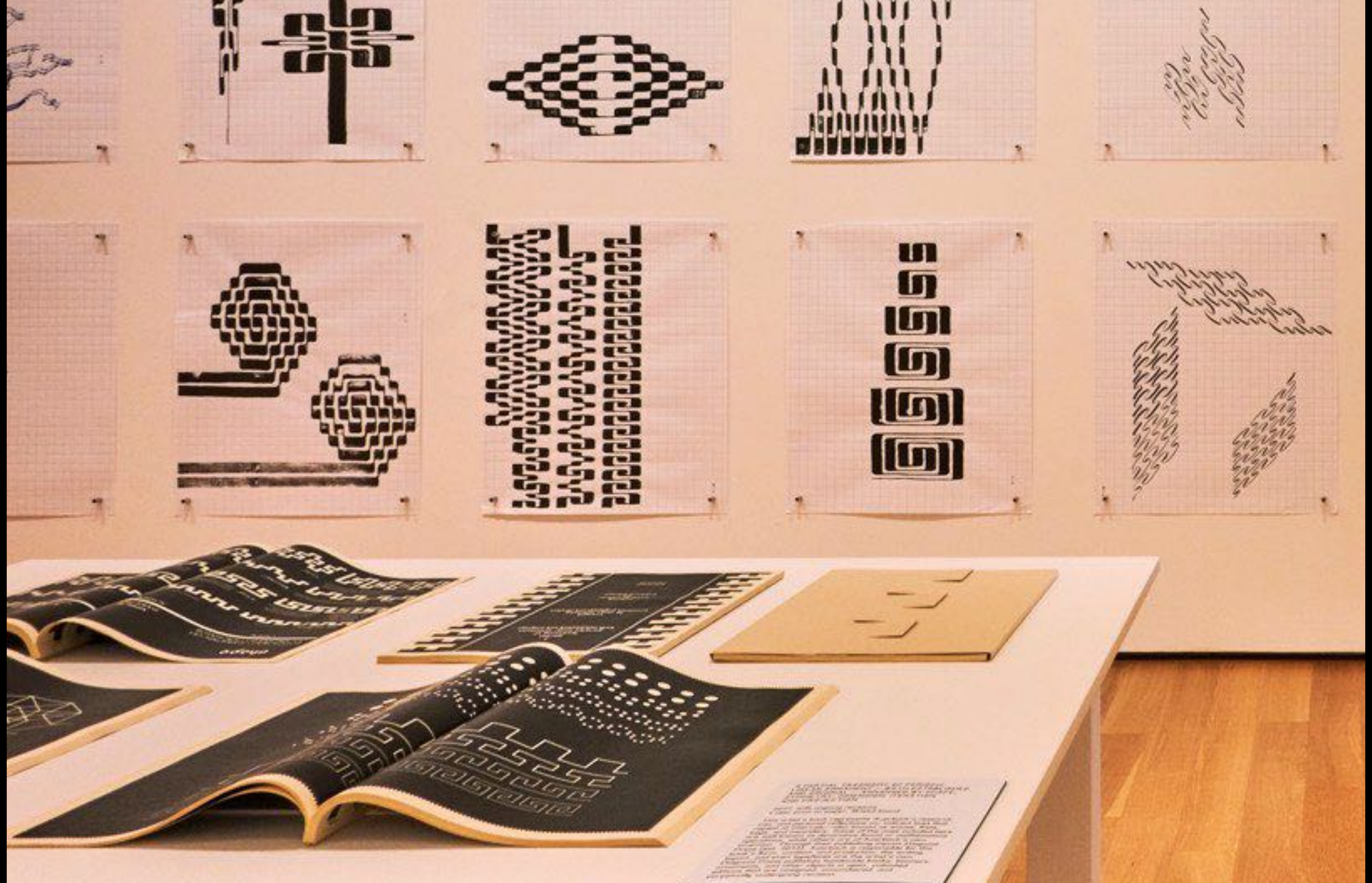
Taubia Auerbach (b. 1981, San Francisco, lives and works in New York) studies patterns present at all scales in the universe in a practice that blends mathematics and science with art, design, and craft. In particular, Auerbach has focused on meandering lines and moved fluidly between different media to interrogate their properties. As the artist has noted, these lines wind their way through human history and the natural world: known as meanders, frets, or keys, they appear in diverse ornamental traditions (ancient Mediterranean, Mesoamerican, and East Asian among them), but also as waveforms in physics, space-filling curves in geometry, and the helices of our DNA. Auerbach traces and transforms these lines in multiple dimensions; if they resonate with us, the artist believes, it might be at a fundamental, even cellular level.



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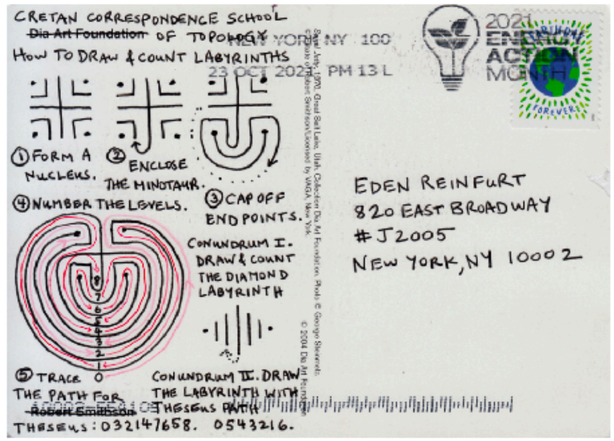

I thought you'd appreciate this postcard since Smithson forgot to build a gift shop on his jetty. His friend Richard said the original design features just a single hook-like hand out in the lake until someone with gestalty imagination asked: do you intend to build a 7,000-ton question mark? So he went spiral. Were the rocks all salt crystalled when you went? Were you tempted to pocket a souvenir? I don't know why I love that alternating boundary of rock/salt/lake/salt/rock/salt/lake/salt so much. Maybe it activates that part of our animal brain drawn to salt licks.

Or it's just that part of my over-schooled math brain that associates it with the Lakes of Wada—a topological conundrum par excellence—consisting of three simply connected bounded regions of the plane that share a single boundary. In Alexandroff's book (the slim black one with the stained-glass barycentric subdivision on the cover, I think your dad has it) there's a mysterious figure of the Lakes with the caption: "Imagine an island in the sea and on it a cold and a warm lake. The following work program is to be carried out on the island. In the course of the first hour canals are to be dug, one from the sea, one from the warm lake, one from the cold lake, in such a way that neither salt and fresh nor warm and cold water come into contact with one another, and so that at the end of the hour every point of land is at a distance of less than one kilometer from each kind of water (i.e. salt, cold, and warm)." The work gets considerably more laborious, as you might expect, in the second hour.

The Cretan labors that I volunteered you for are hopefully less maddening. Or at least interesting enough to elicit conundrums to carry out on your own terms. Like, what happens when I cap a nucleus off wily-nilly?

– Philip

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EXERCISE