SHUTTERING MECHANISMS OF ZOETROPE AND ZOOPRAXISCOPE

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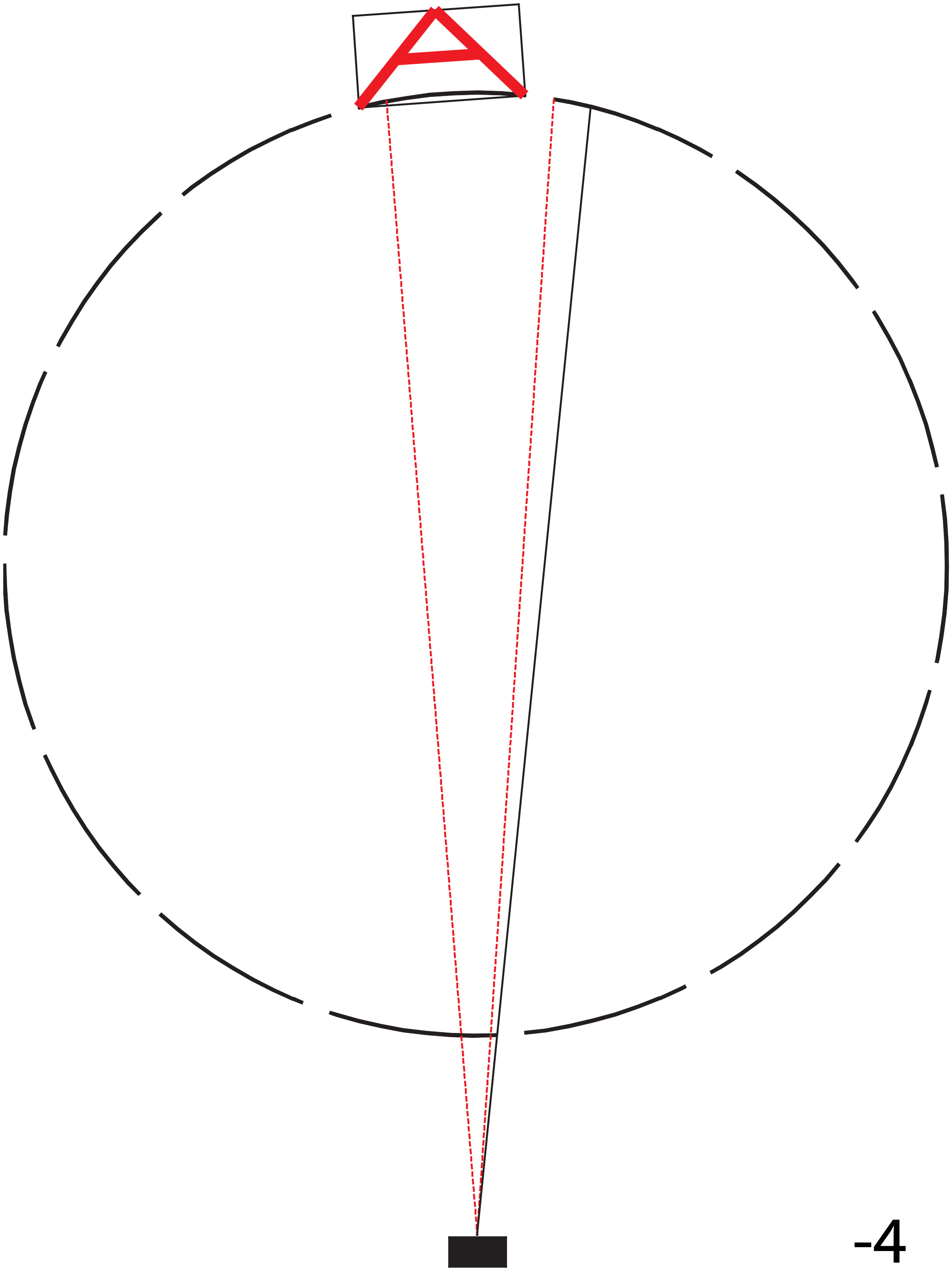
I've been puzzled for years about exactly how the shuttering mechanixms of a zoetrope and a zoopraxiscope actually work. In both cases, I've tried to "see" what happens in my mind but have found my imagination not up to the task. Perhaps others have similarly found the mechanisms baffling. In particular, I wanted to understand why the zoopraxiscope foreshortens its frames. So here construct careful geometric simulations of each mechanism, to show in detail what happens. The exercises have worked well for me, so I'd like to share them.

First, I construct a careful geometric simulation of a zoetrope, assuming that the eye position and direction remains fixed. (This description assumes the zoetrope is spinning clockwise as seen looking down at its top.) The simulation reveals a slightly more complex, and surprising, story than I first suspected. The next still is not suddenly revealed in its entirety as its corresponding slit appears. What the eye actually sees is the next still revealed smoothly from the right then obscured smoothly from the right. Only at one instant is the entire frame revealed—at the halfway point. Recall that the drum is always in motion. So the next still is actually moving to the right as seen through the slit, and its slit is moving to the left. The total effect, however, is that the frame appears still on the eye (assuming persistence of vision), revealed as the left edge of its slit moves left, then obscured as the right edge of its slit moves left. The steps of the zoetrope simulation appear in Section 1. The tiny image at the bottom of each step shows what the eye sees, when the full frame on the opposite side of the zoetrope is the letter A. The dotted red lines represent the fixed view of a human eye.

Second, I construct a careful geometric simulation of a zoopraxiscope, assuming that the eye position and direction remain fixed. I simulate a 12-frame disc, using letters of the alphabet for images. The shutter is a disc of the same size but opaque except for 12 radial slits cut into its circumference (cf. the photograph in Ball (2013), 367).[1] The depth of each slit was sufficient to reveal the full height of each frame, but the slit width revealed only about one tenth the frame width at any one instant. At each step of the simulation the disc of images rotates one degree clockwise, and the shutter disc rotates one degree counterclockwise. The parts of the frame visible at each increment are accumulated as they are revealed. It is supposed that this accumulation is also accomplished by persistence of vision on a human retina. The result of 15 steps, where the projected frame holds the letter A, is a squeezed A. The height is correct but the width had been reduced substantially. An A of base width 1.375 inches is squeezed before projection to an A with base width 1 inch—approximately a 72.7% reduction. To project a convincing image of a horse, say, the version of the horse on the disc frame would have to be elongated by the inverse, or about 137.5%. The simulated zoopraxiscope is simply my invention, bearing only an approximate resemblance to Muybridge's, but the principle is clear: The continuous rotating shutter mechanism causes obvious foreshortening of the frames on the disc. Furthermore, the letter A resulting from this simulation—the frame as projected—is a rather ragged approximation of the letter A in the actual frame on the disc. The steps of the zoopraxiscope simulation appear in Section 2. At the bottom of each step the accumulated image is shown, presumably what an eye in that position would see. Note that the shutter is removed from the first and last steps (in parenthetical views) to show the frames hidden from view.

[1] Edward Ball, *The Inventor and the Tycoon*, New York: Doubleday, 2013.

Section 1: The Shuttering Mechanism of the Zoetrope



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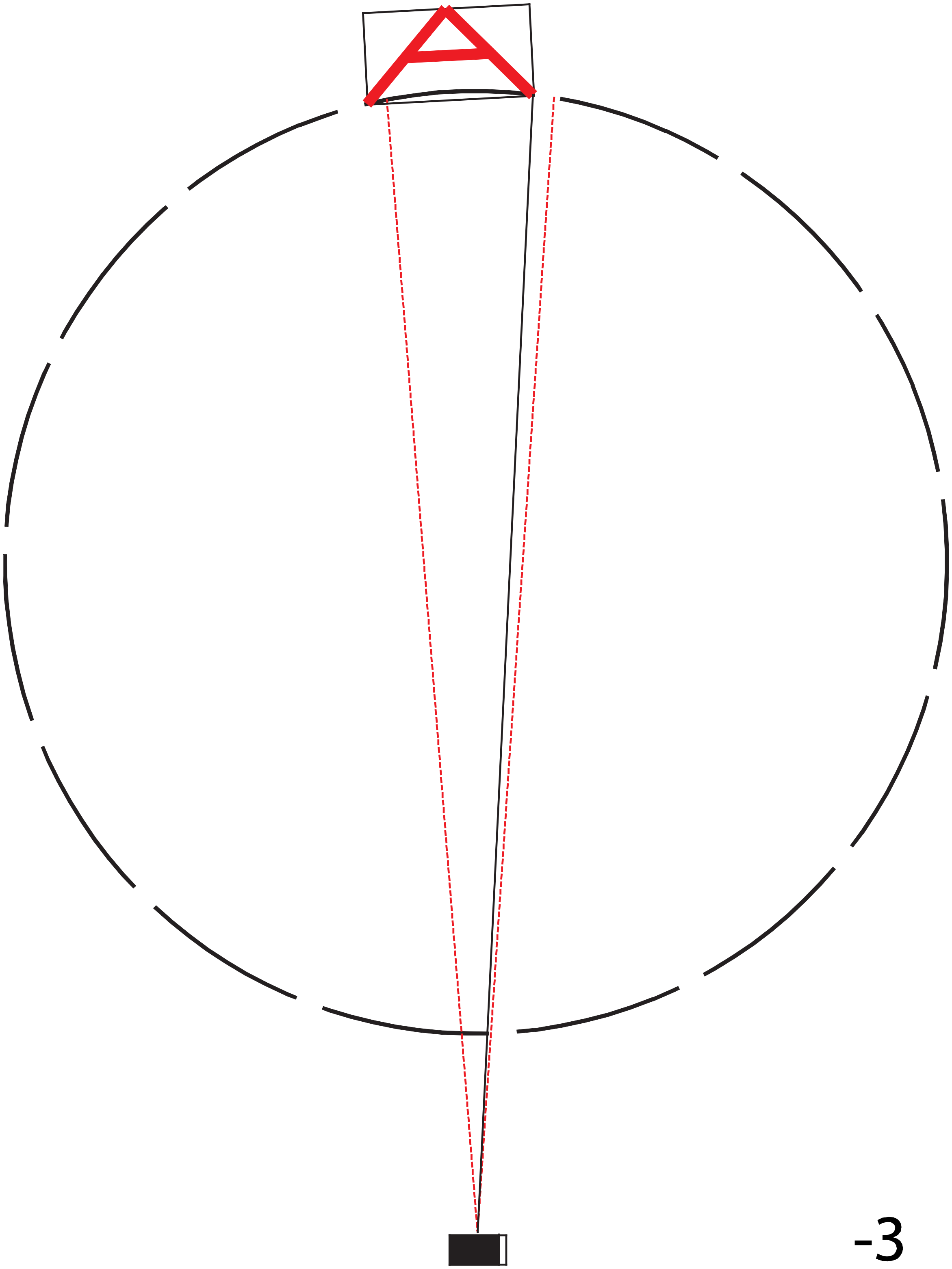

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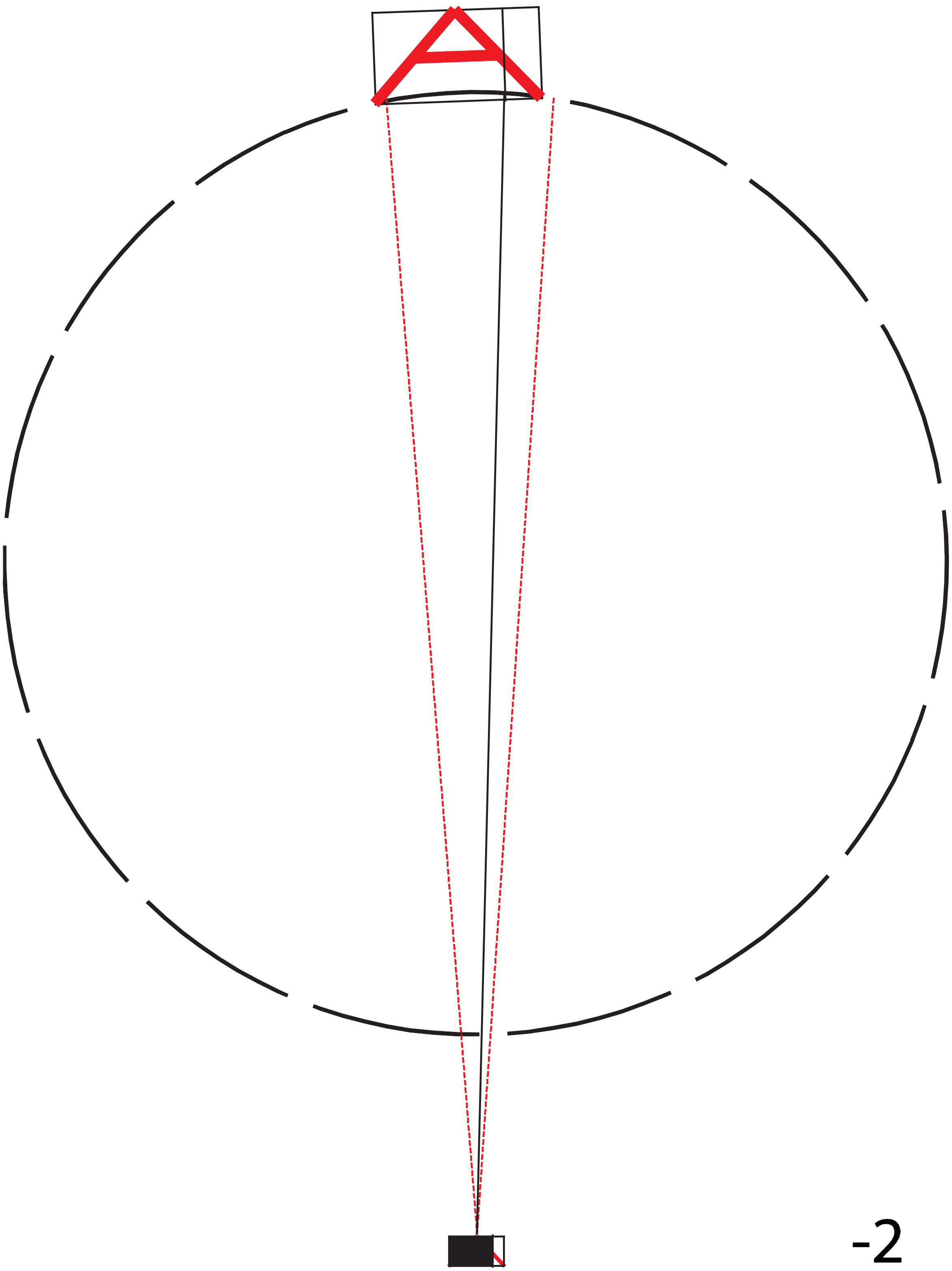

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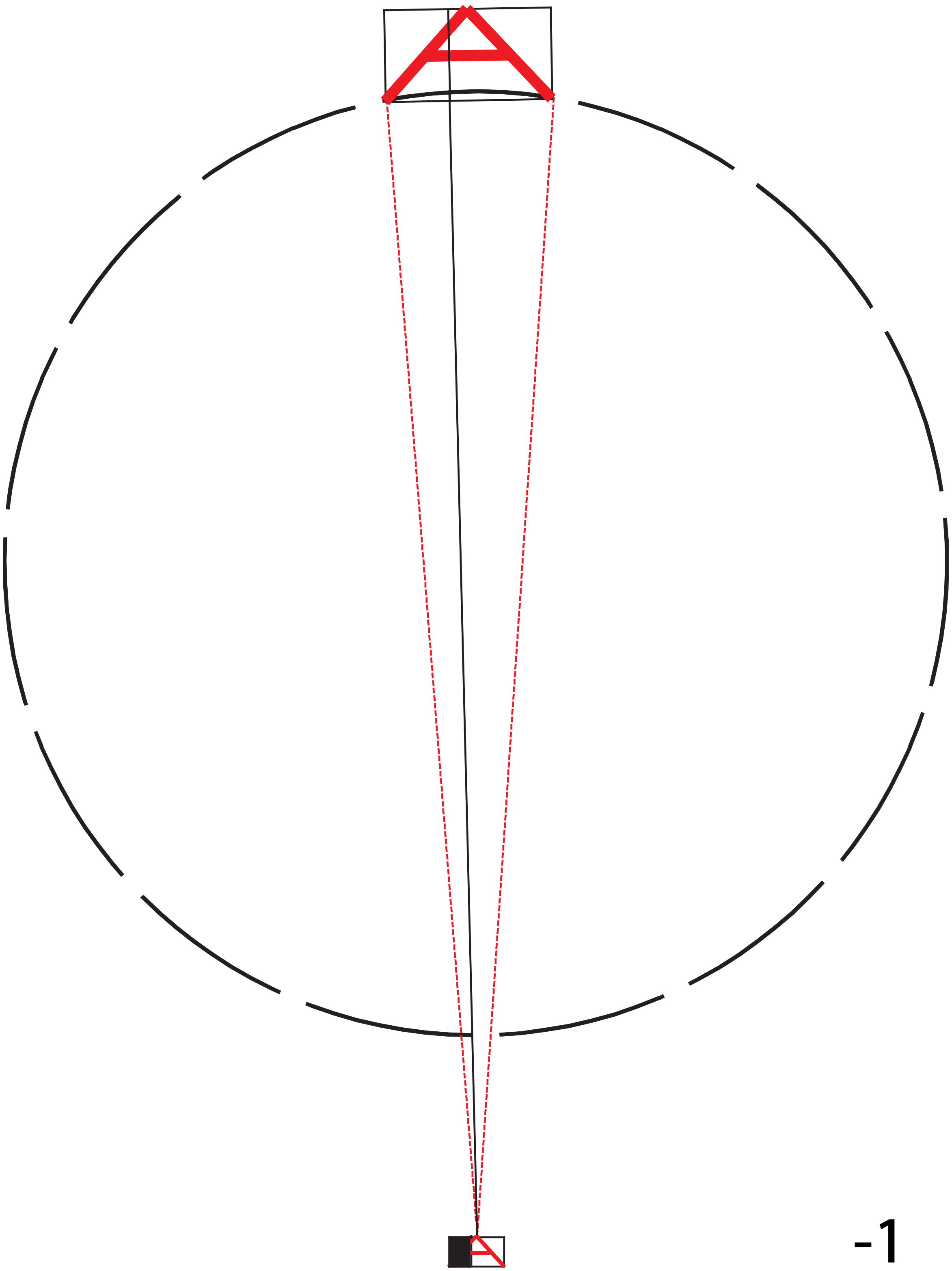

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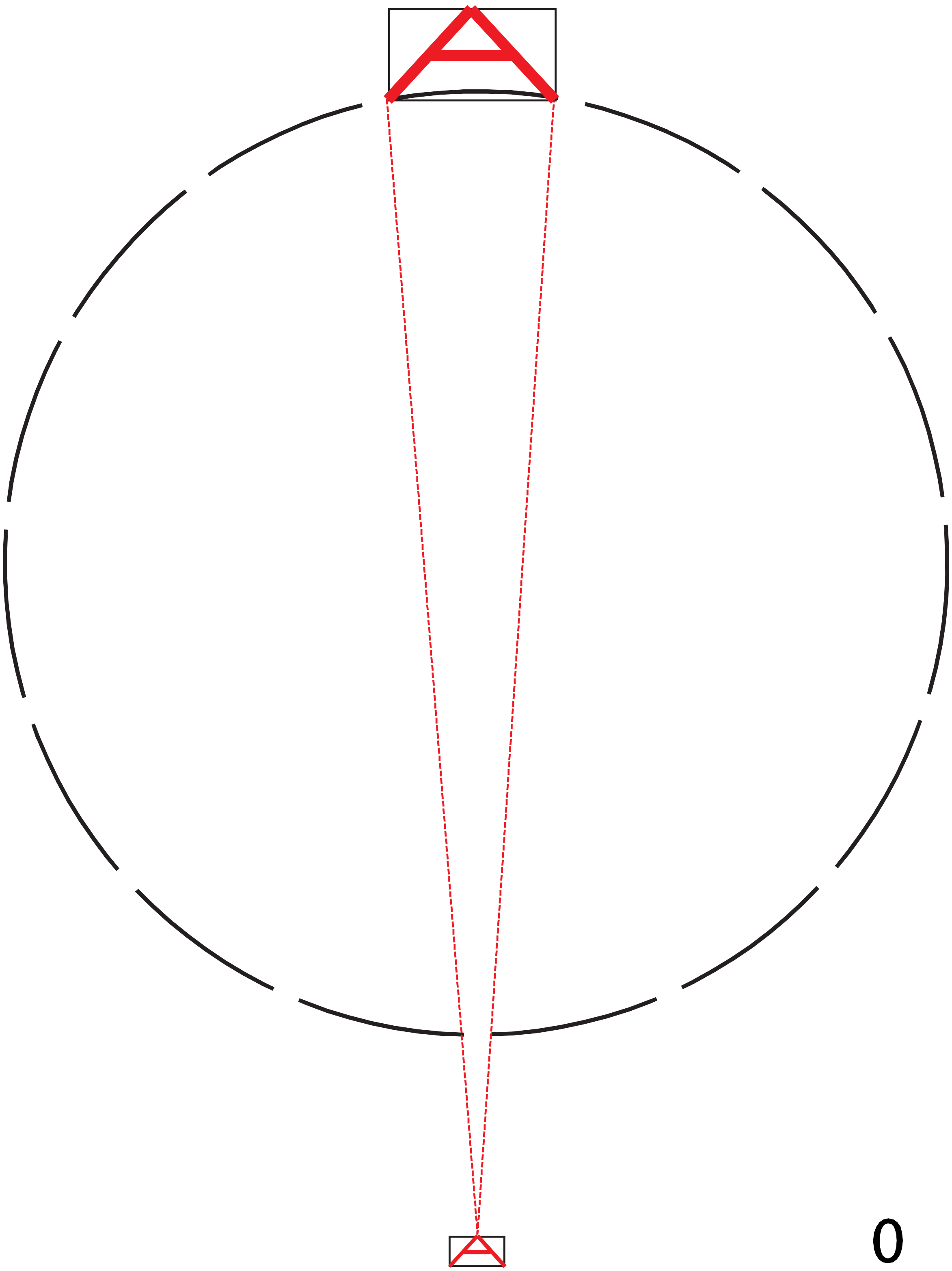

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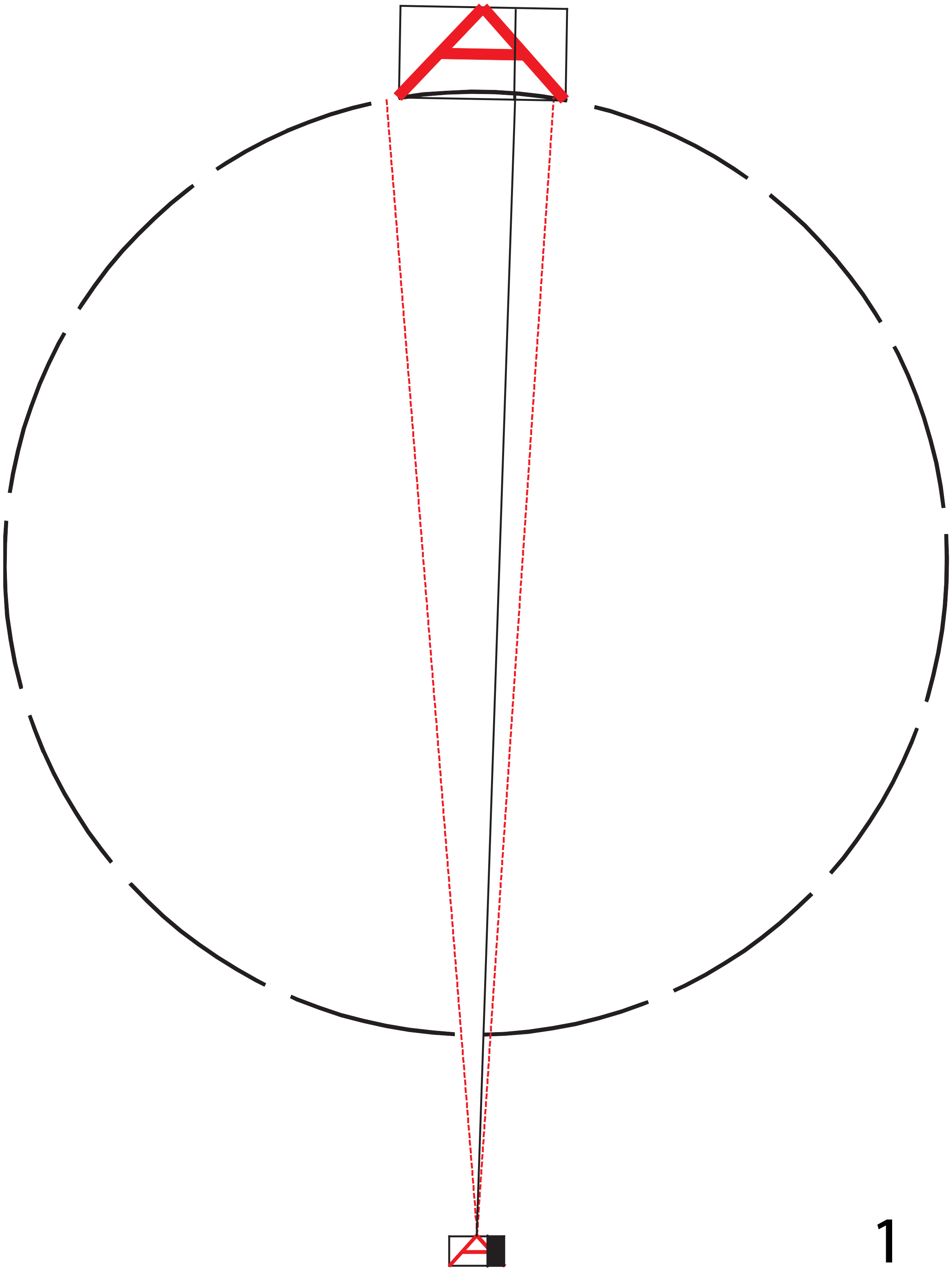

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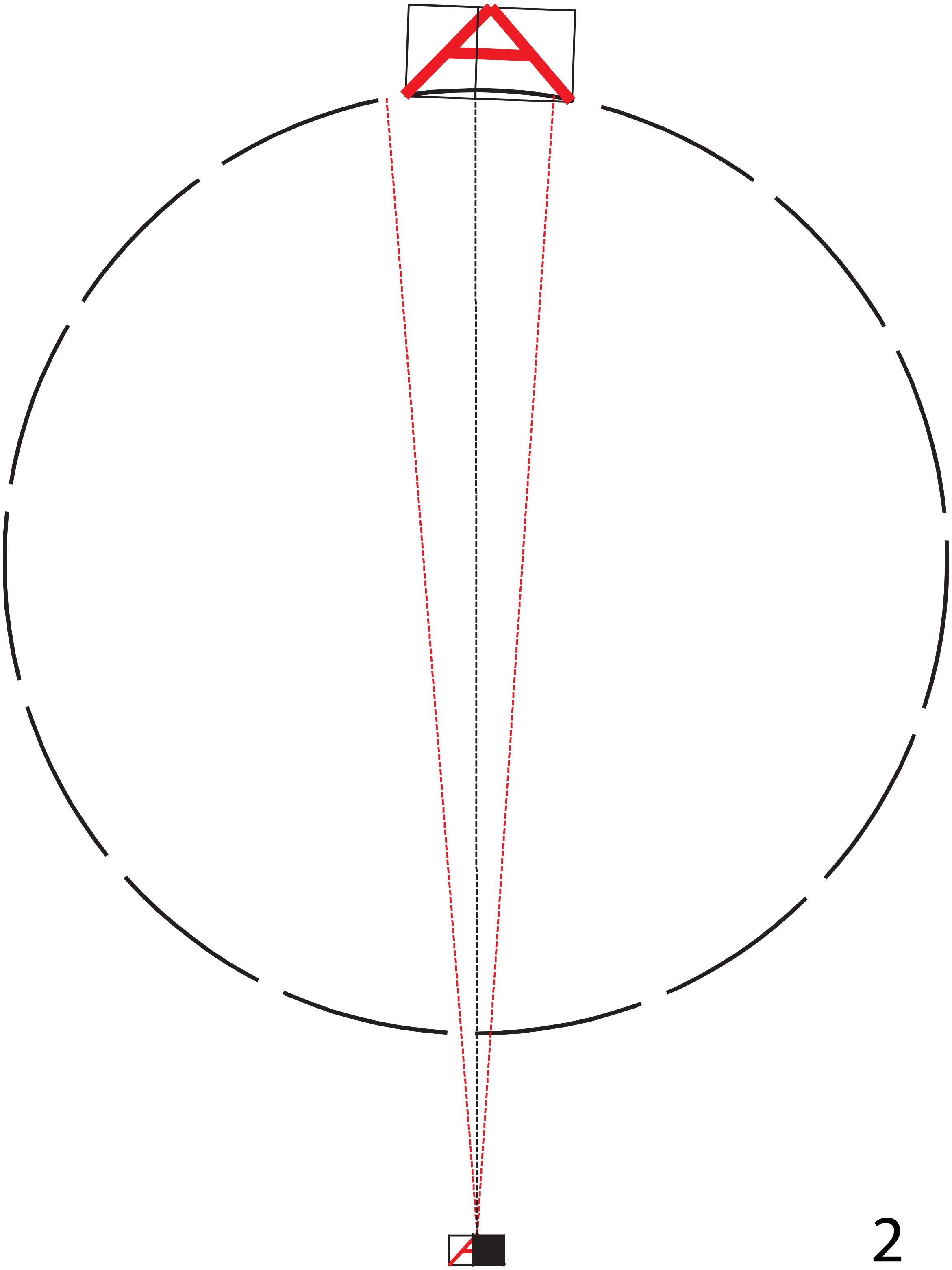
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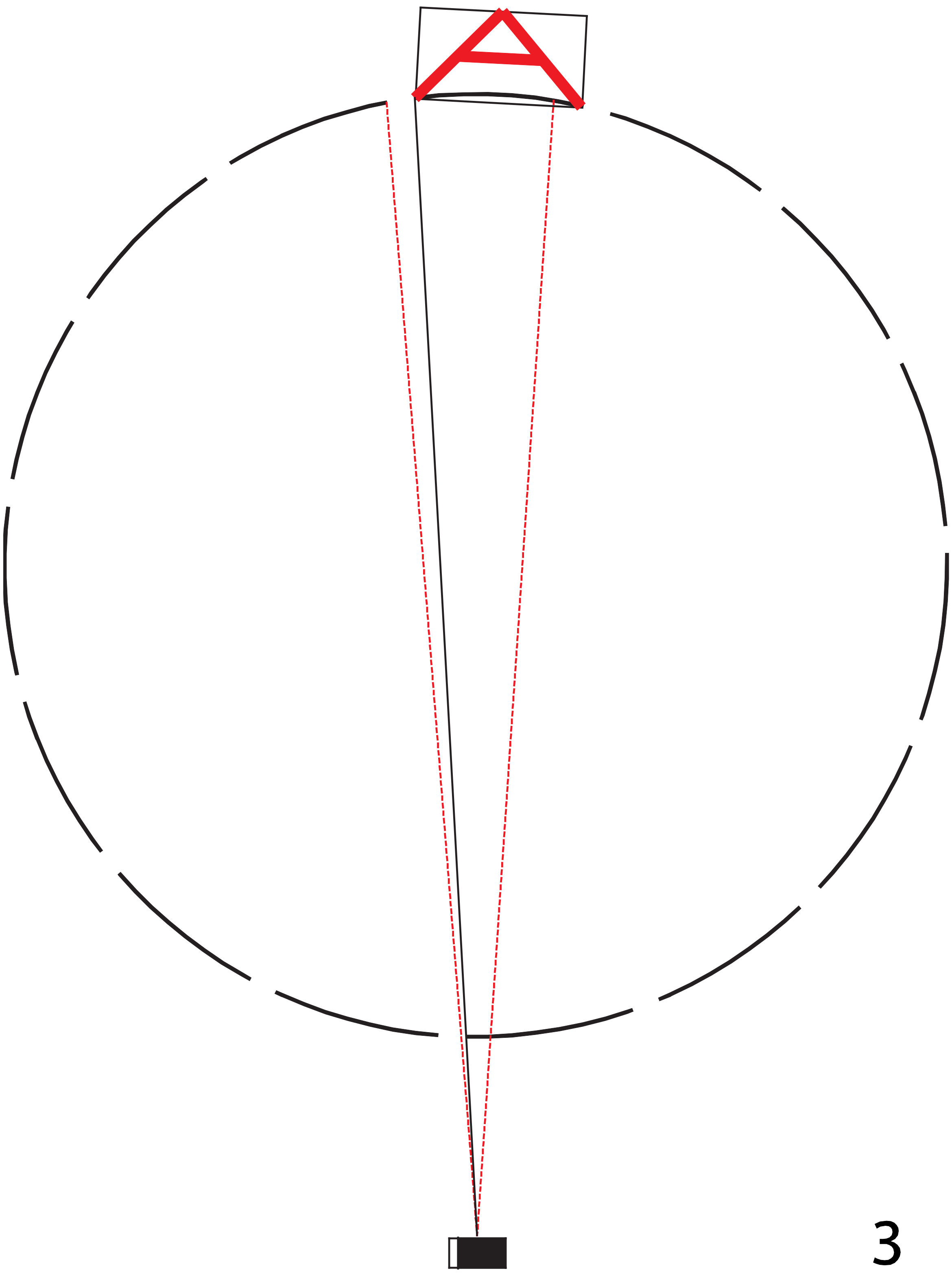
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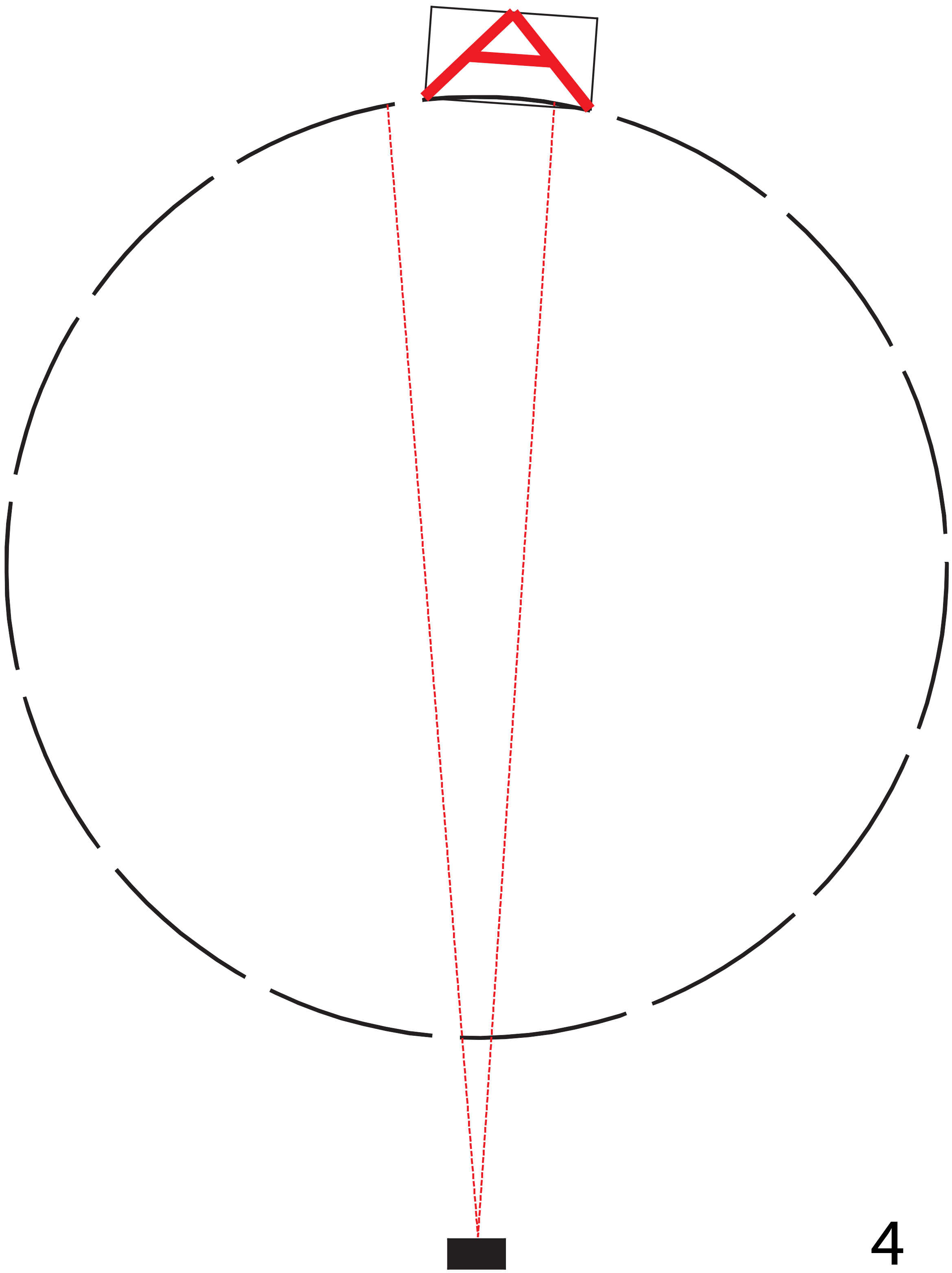
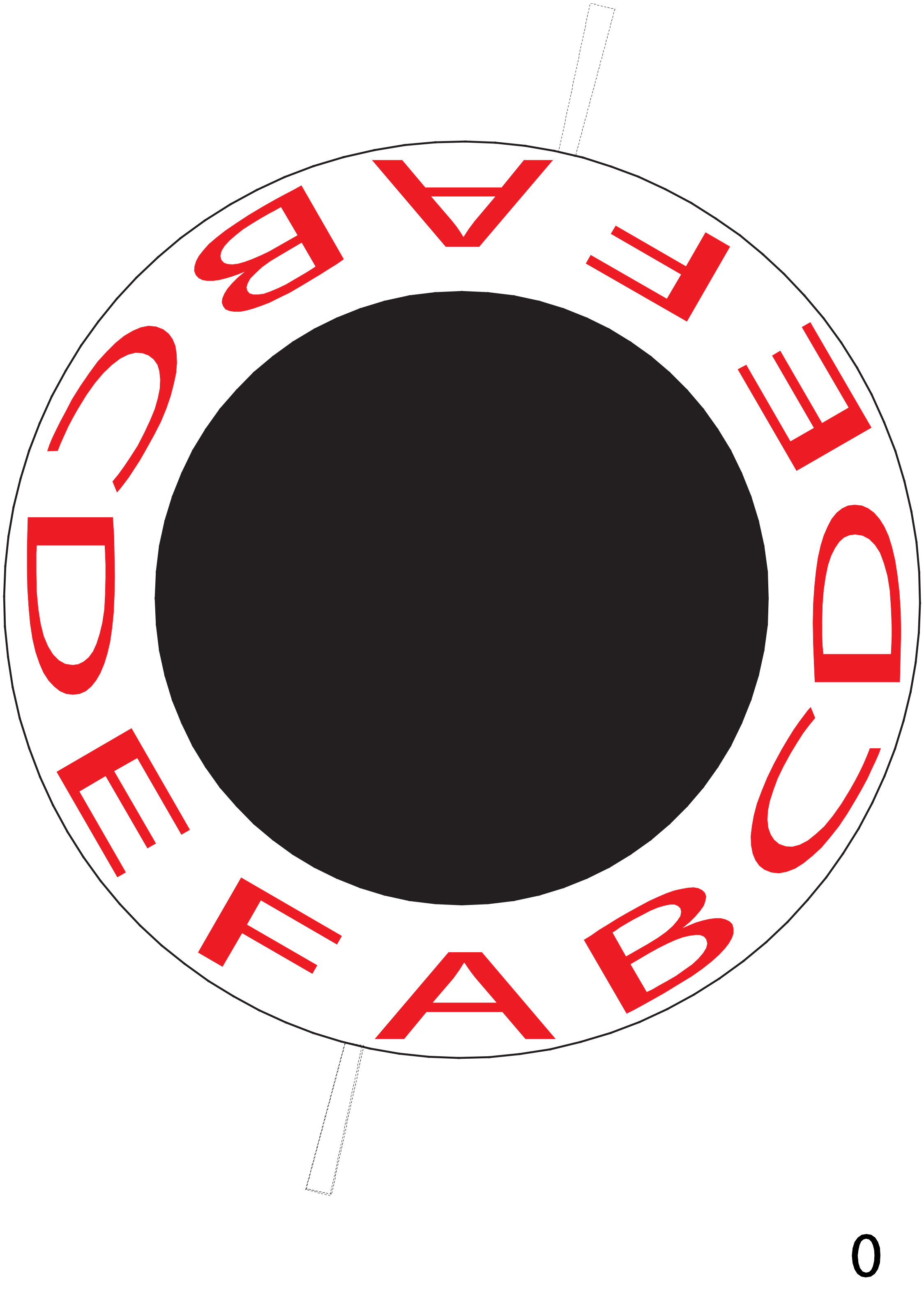


Section 2: The Shuttering Mechanism of the Zoopraxiscope



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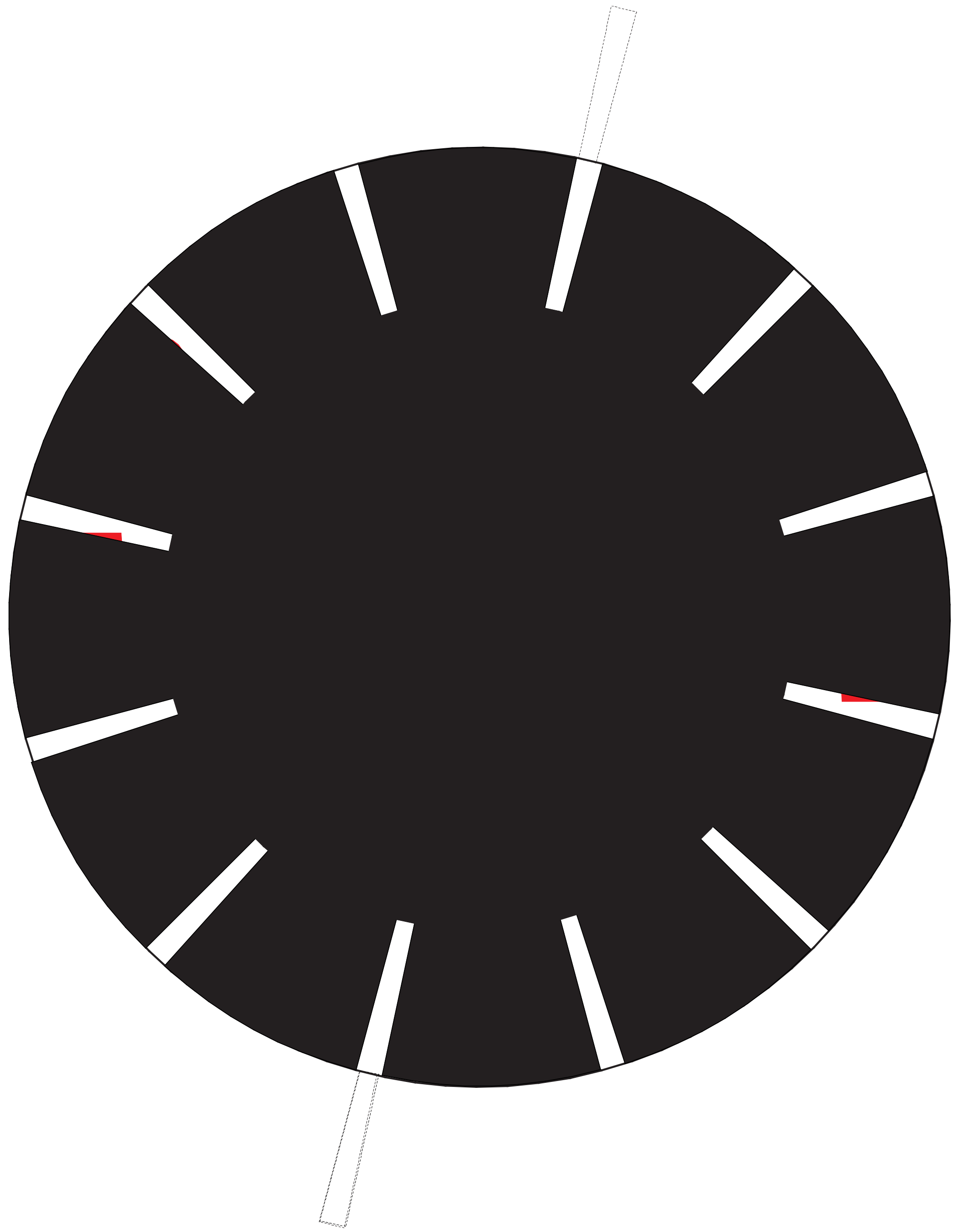

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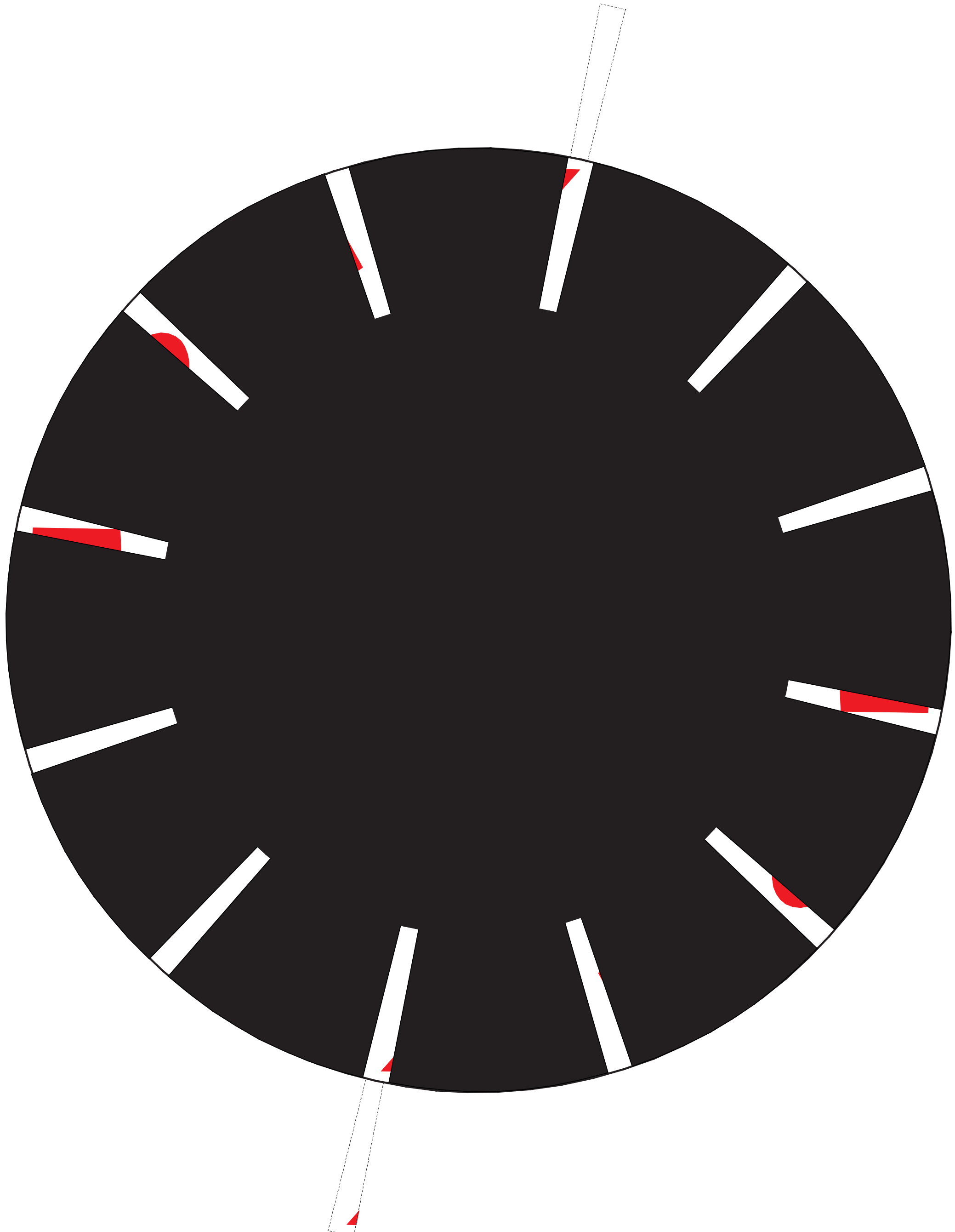

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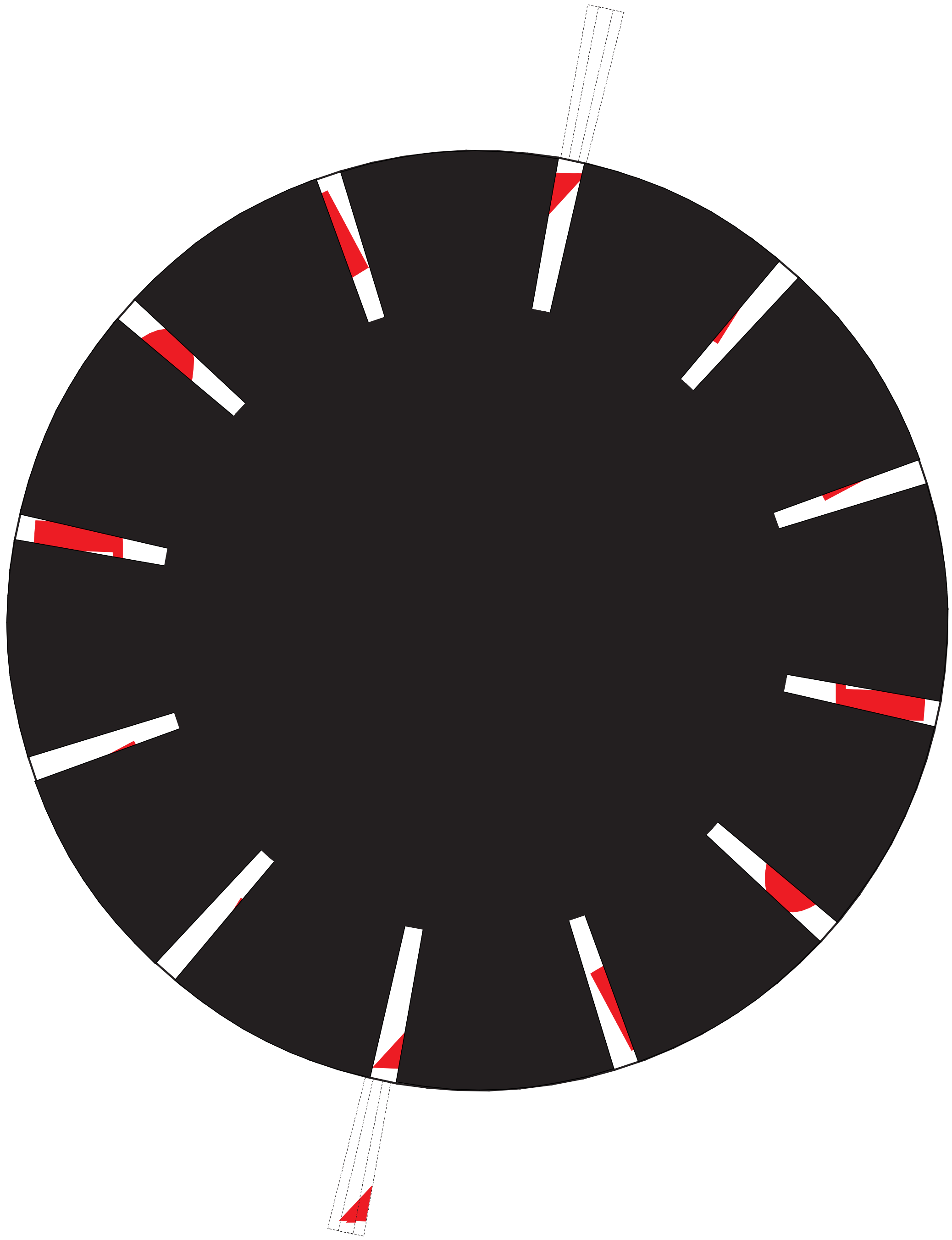

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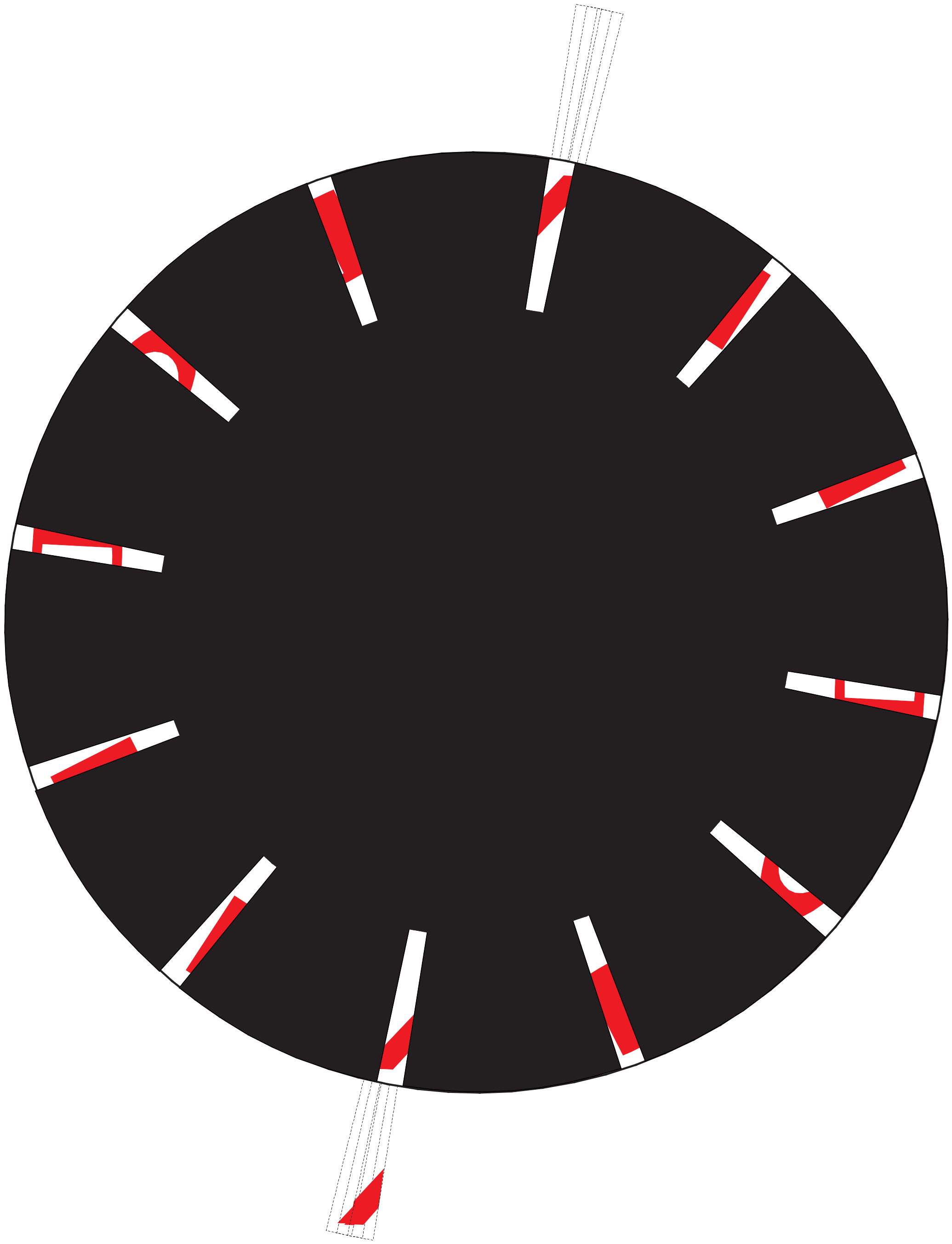

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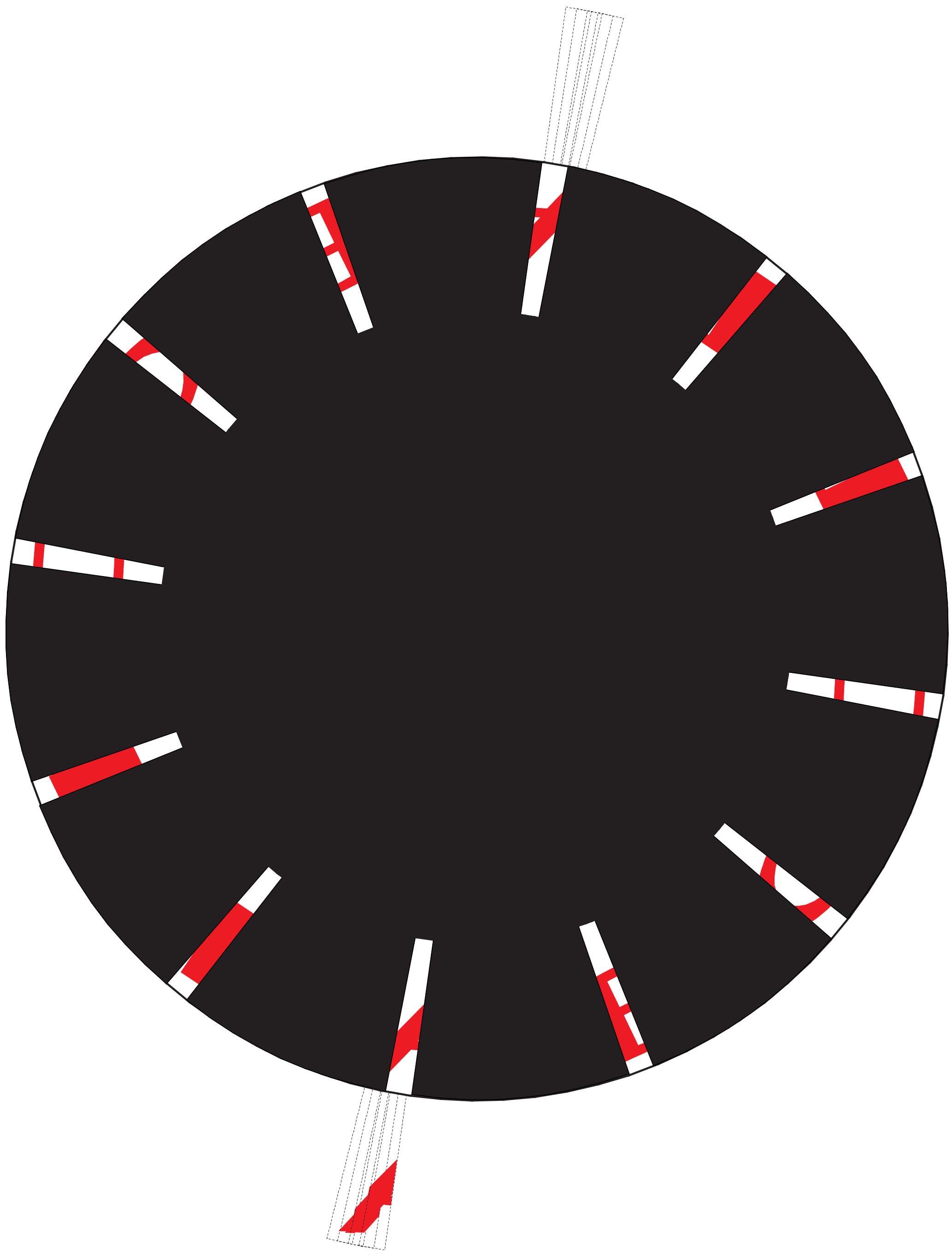

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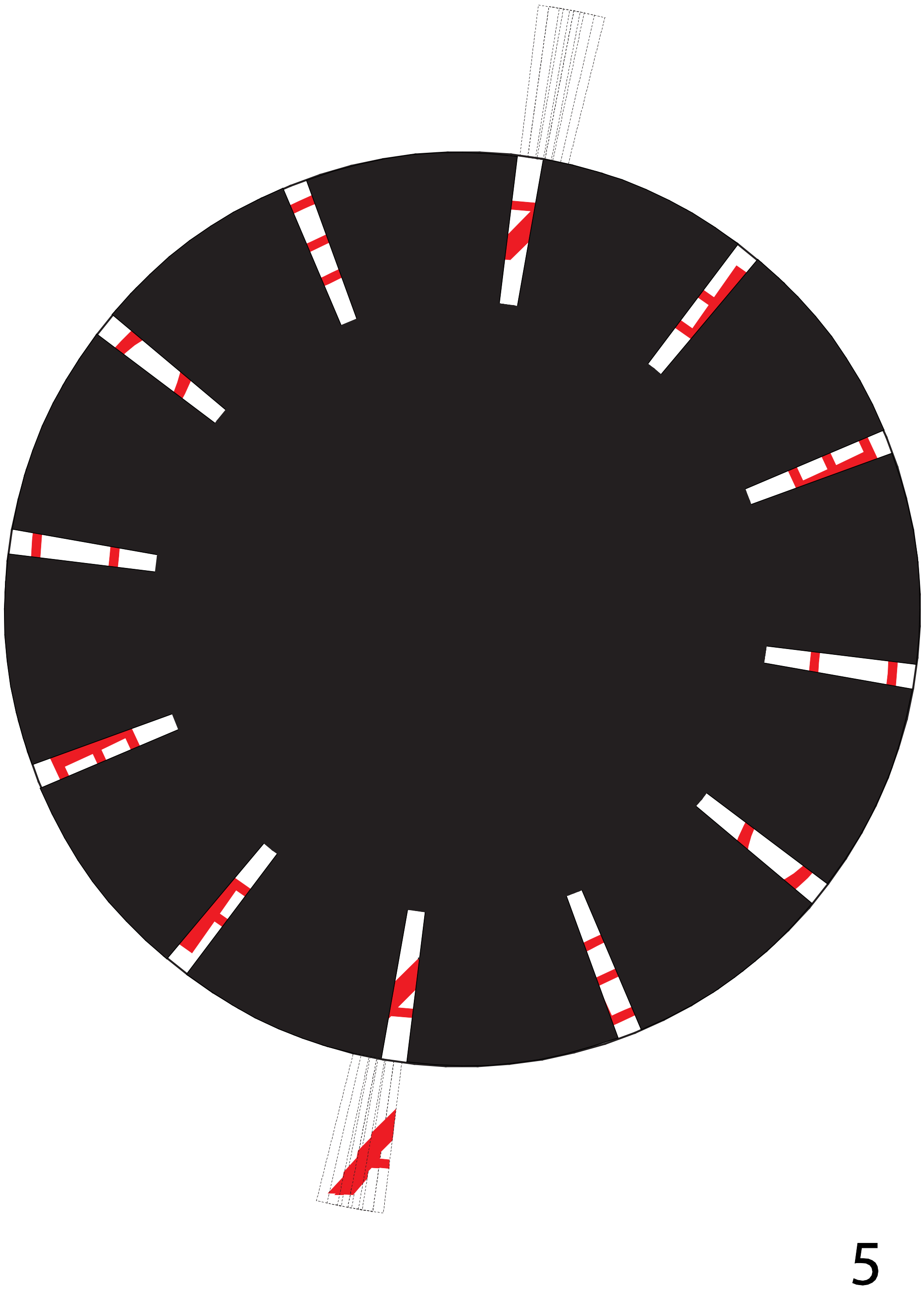

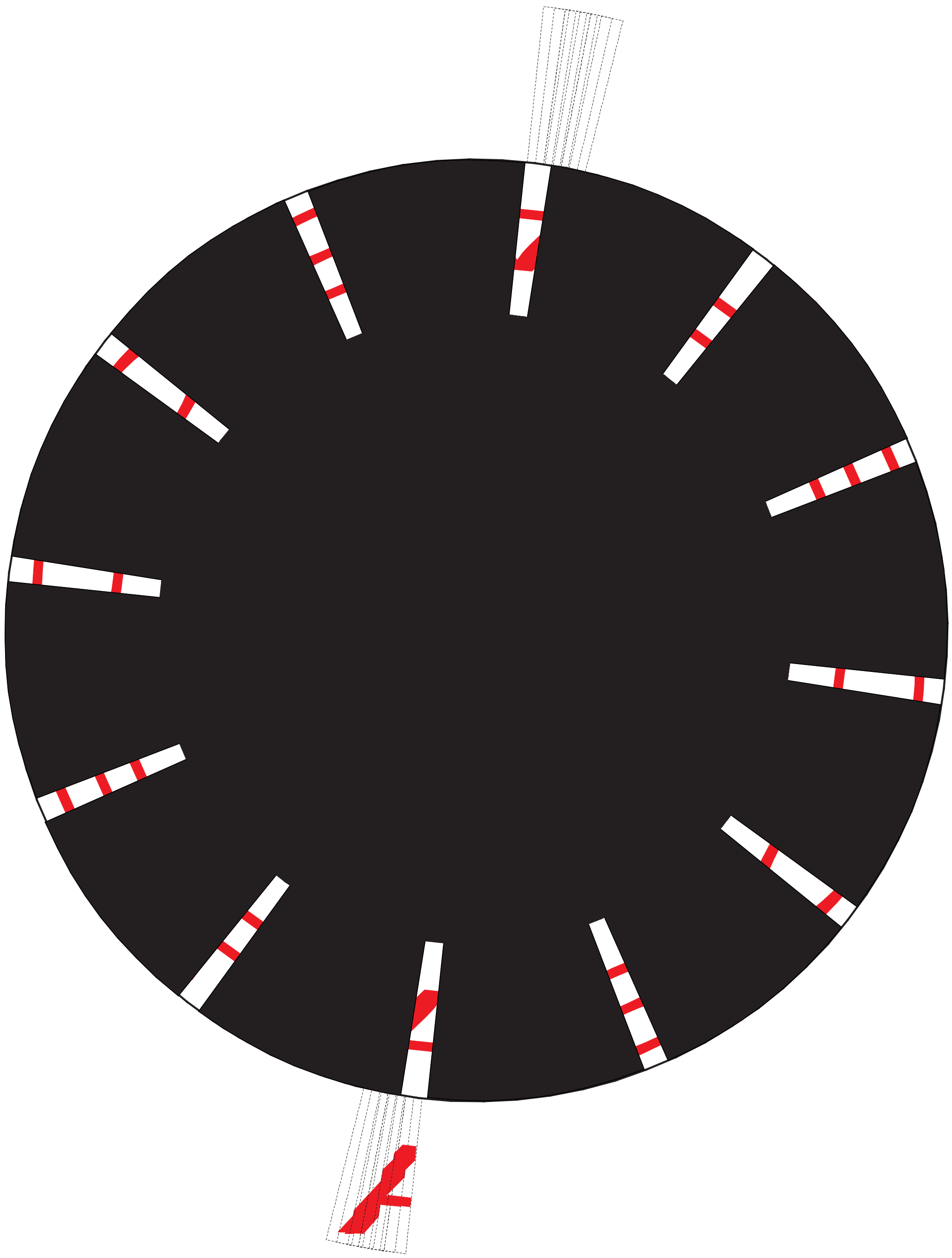

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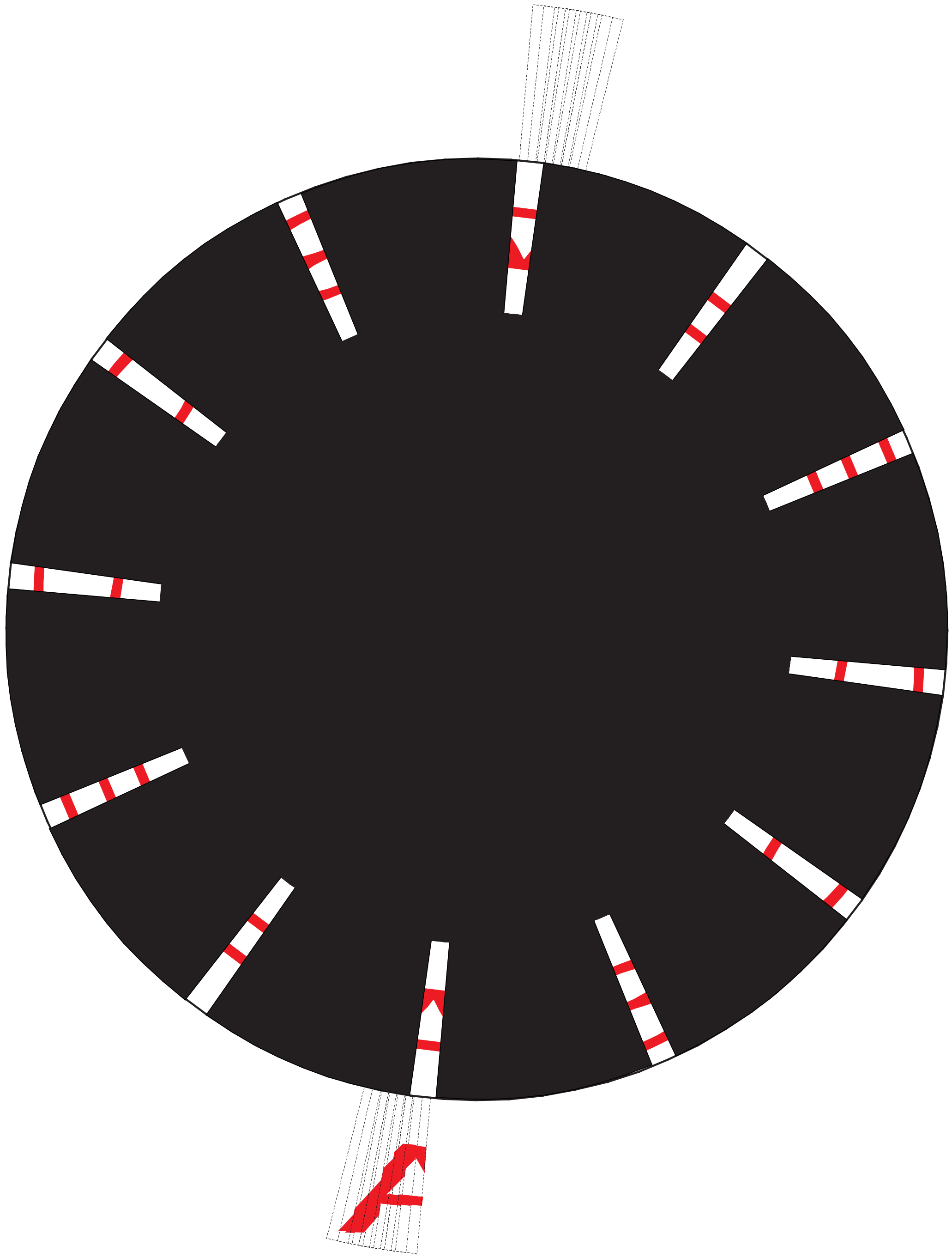

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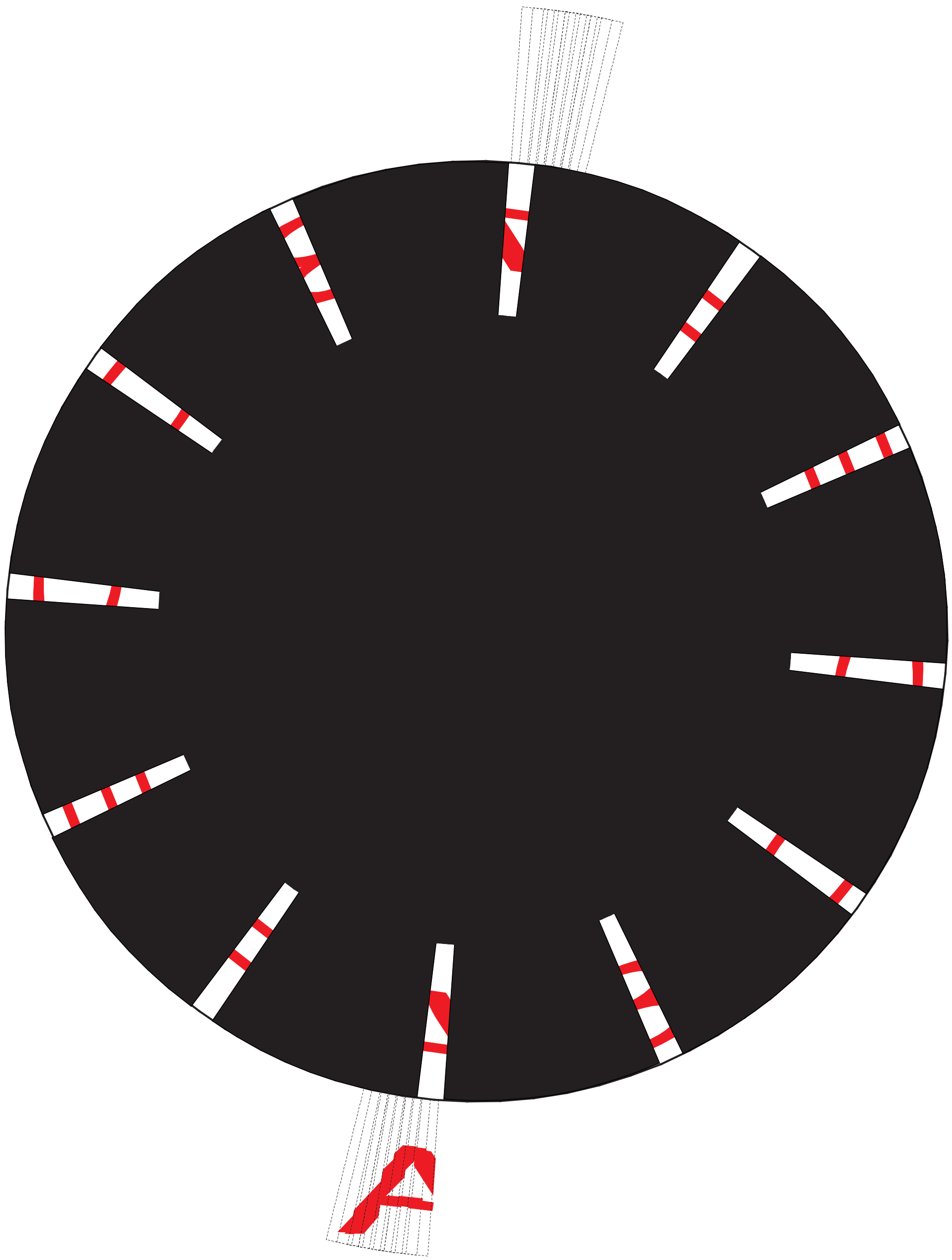

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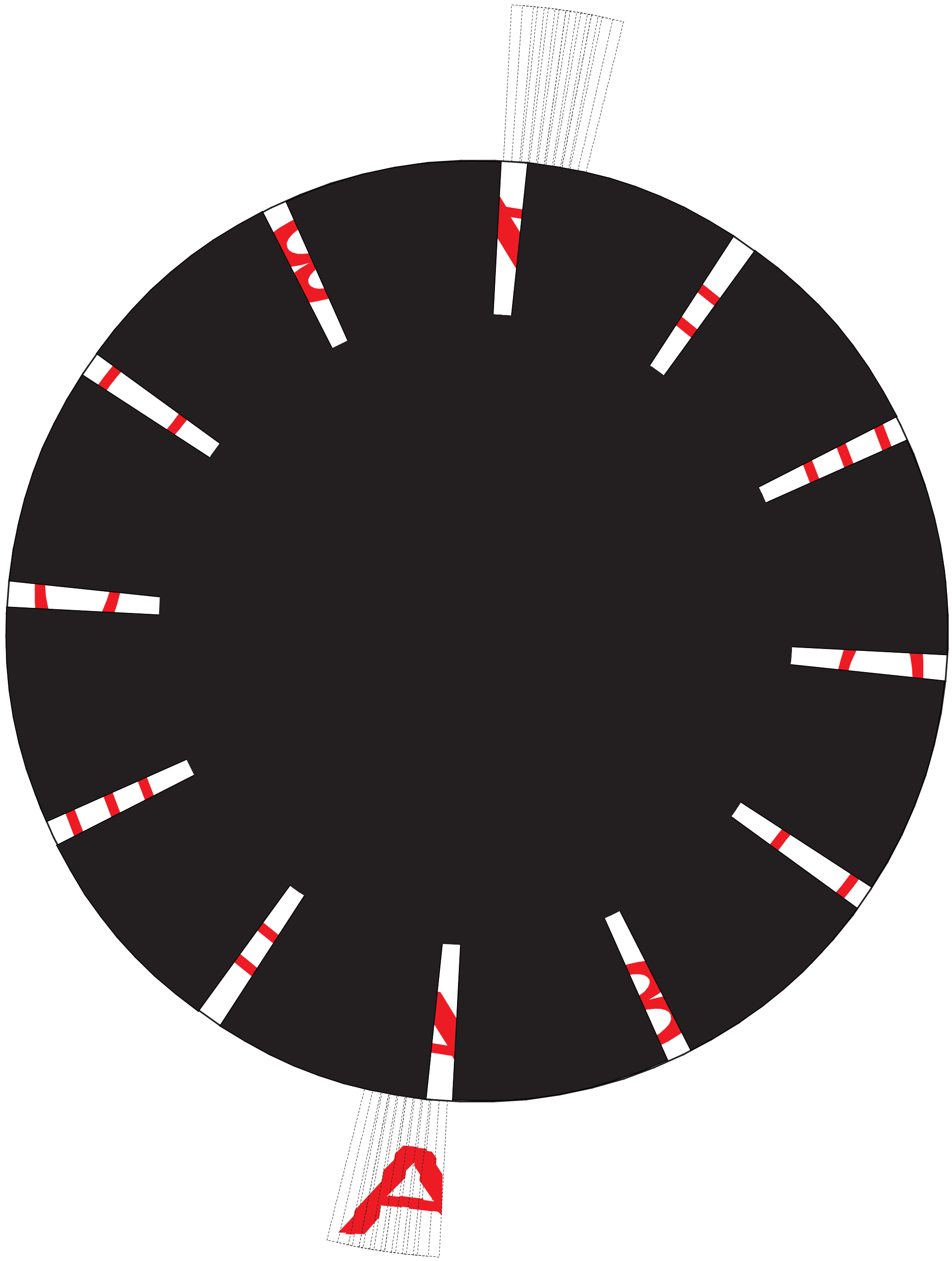

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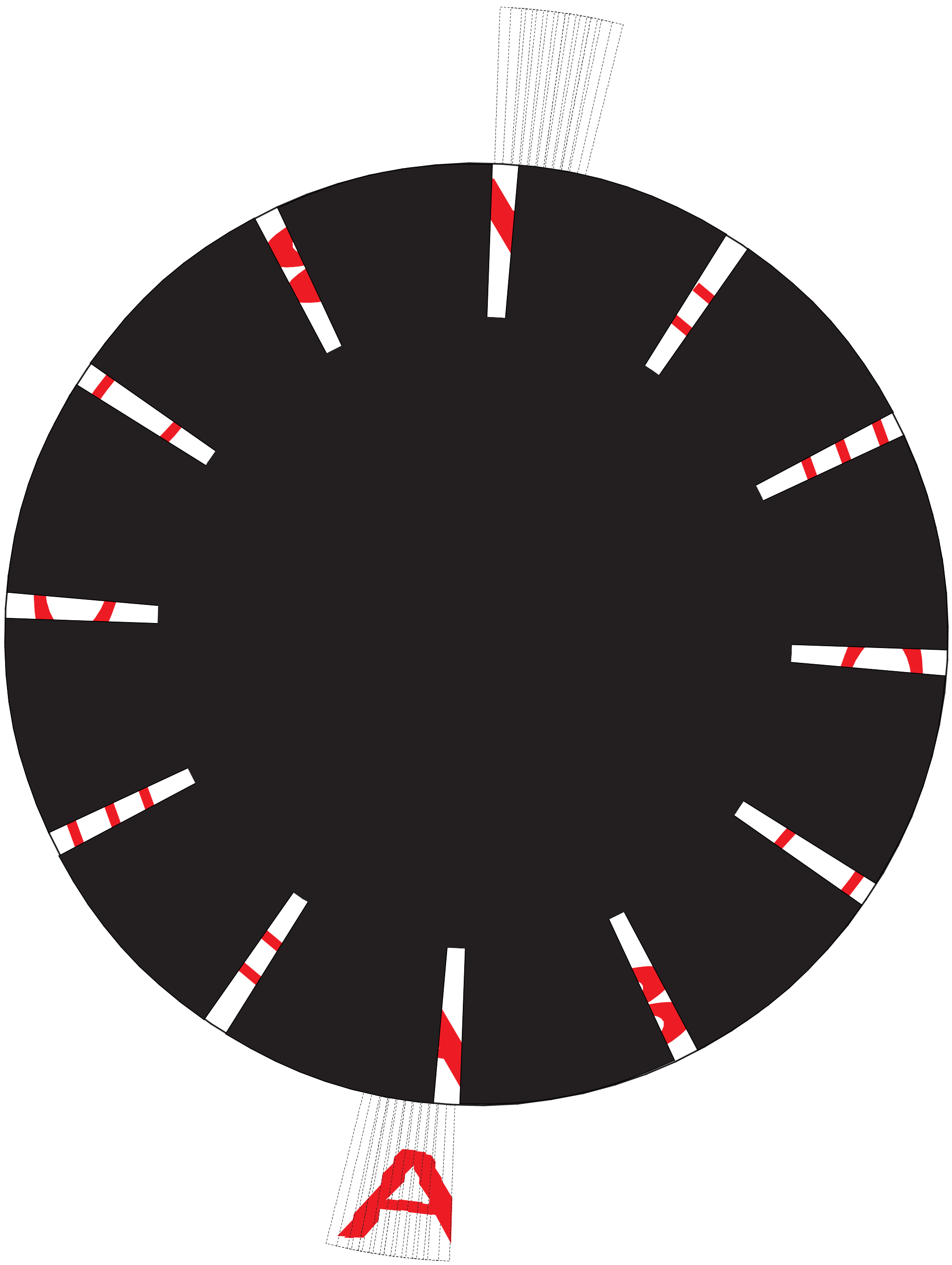

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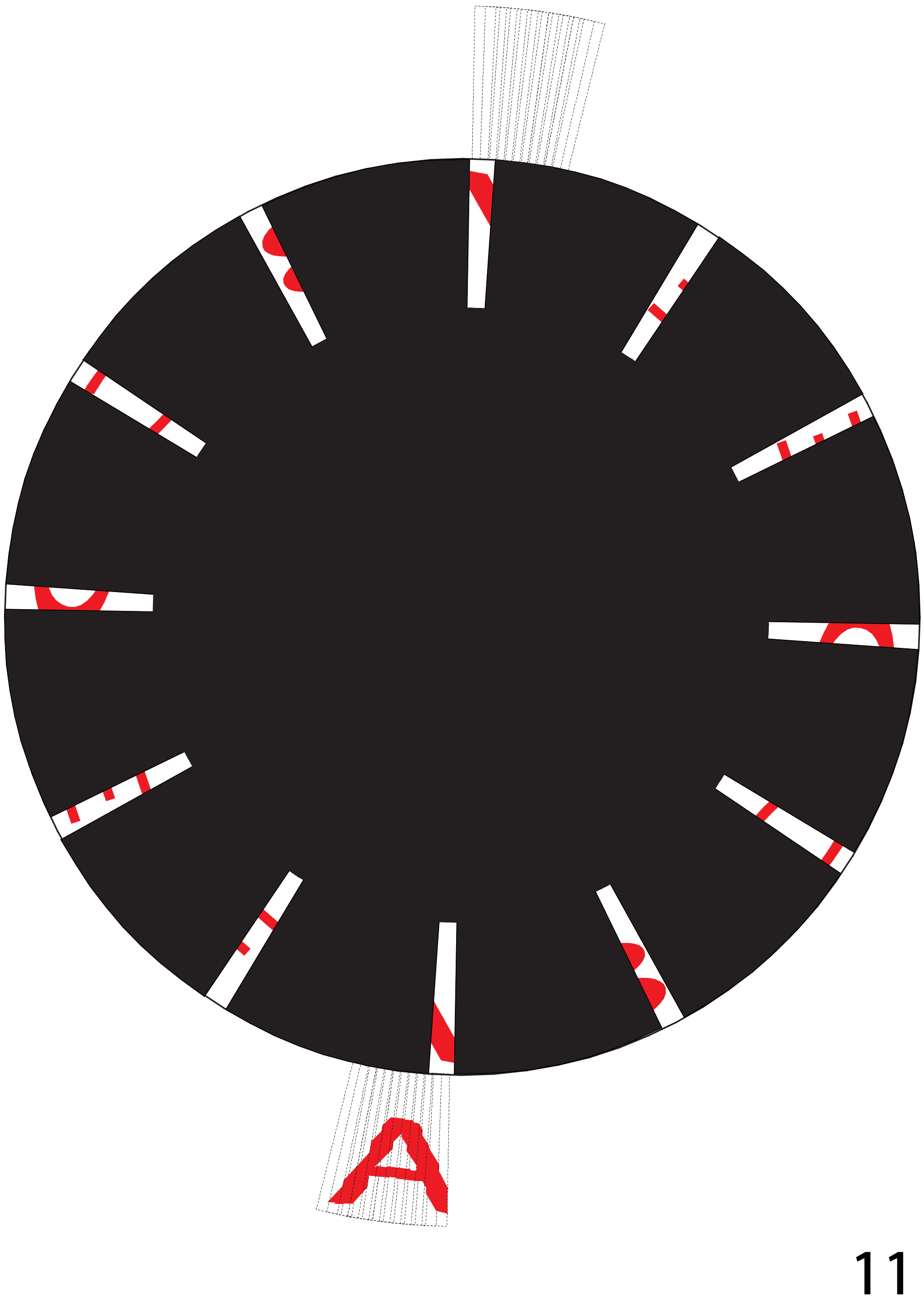

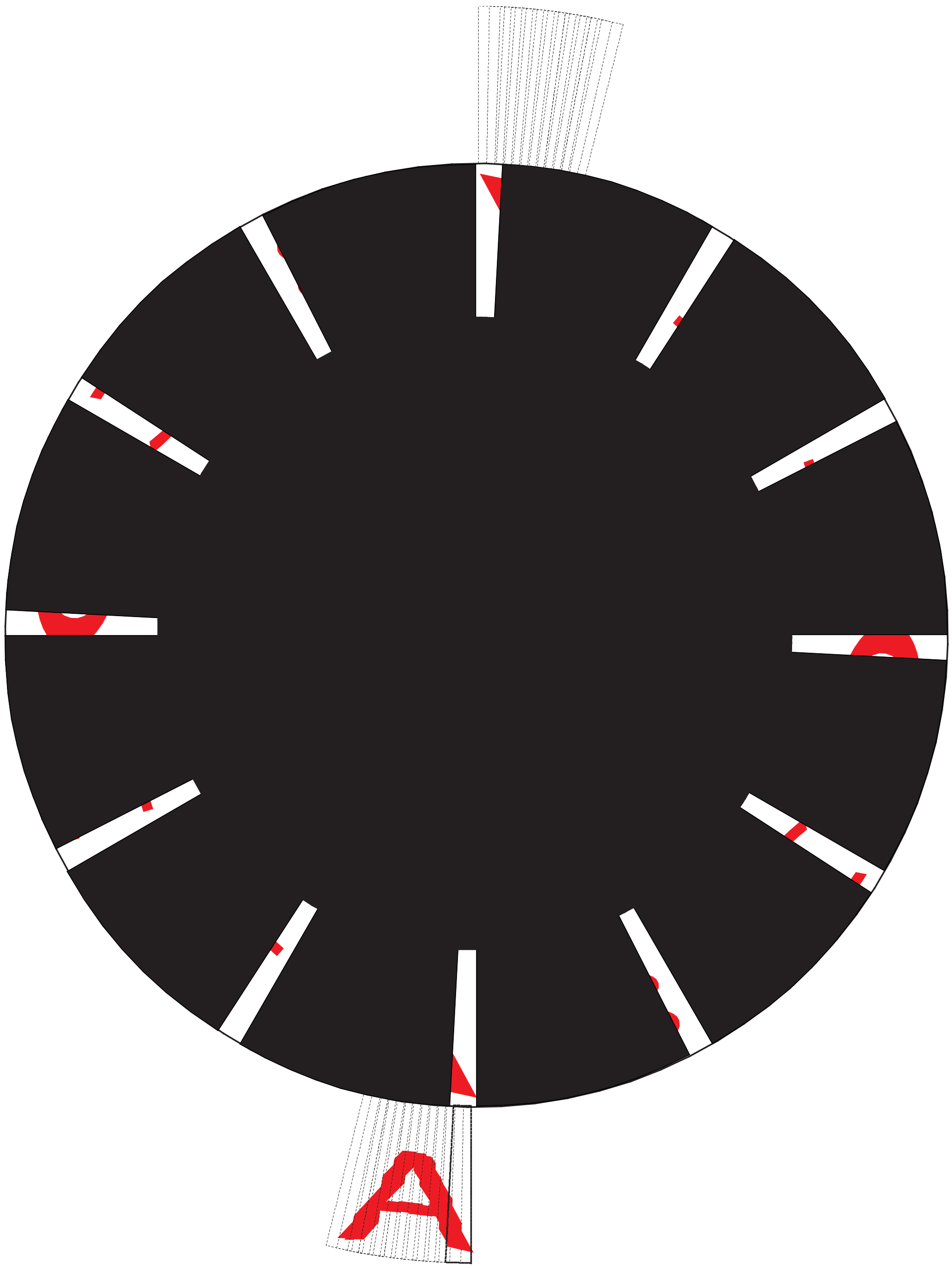

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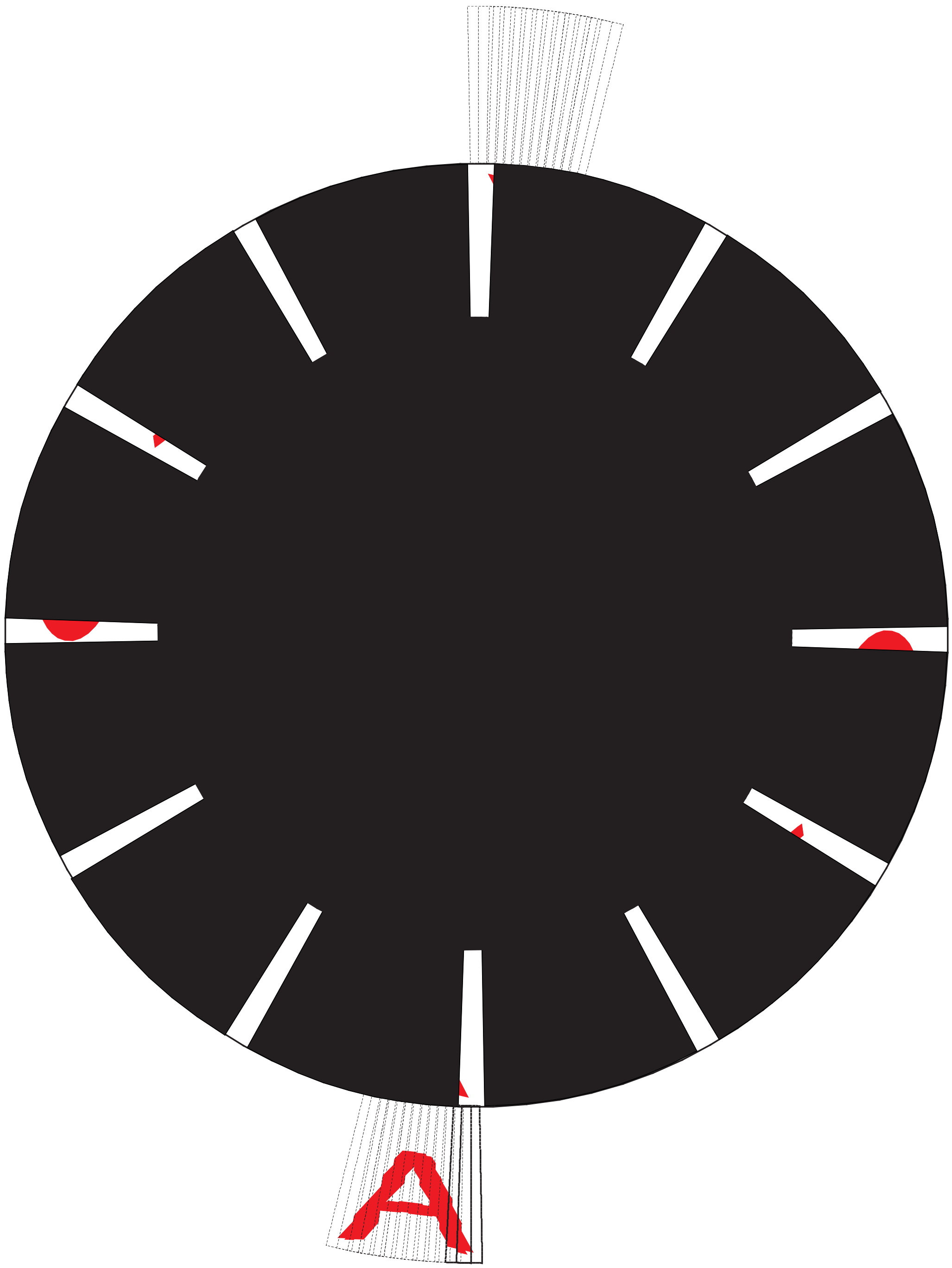

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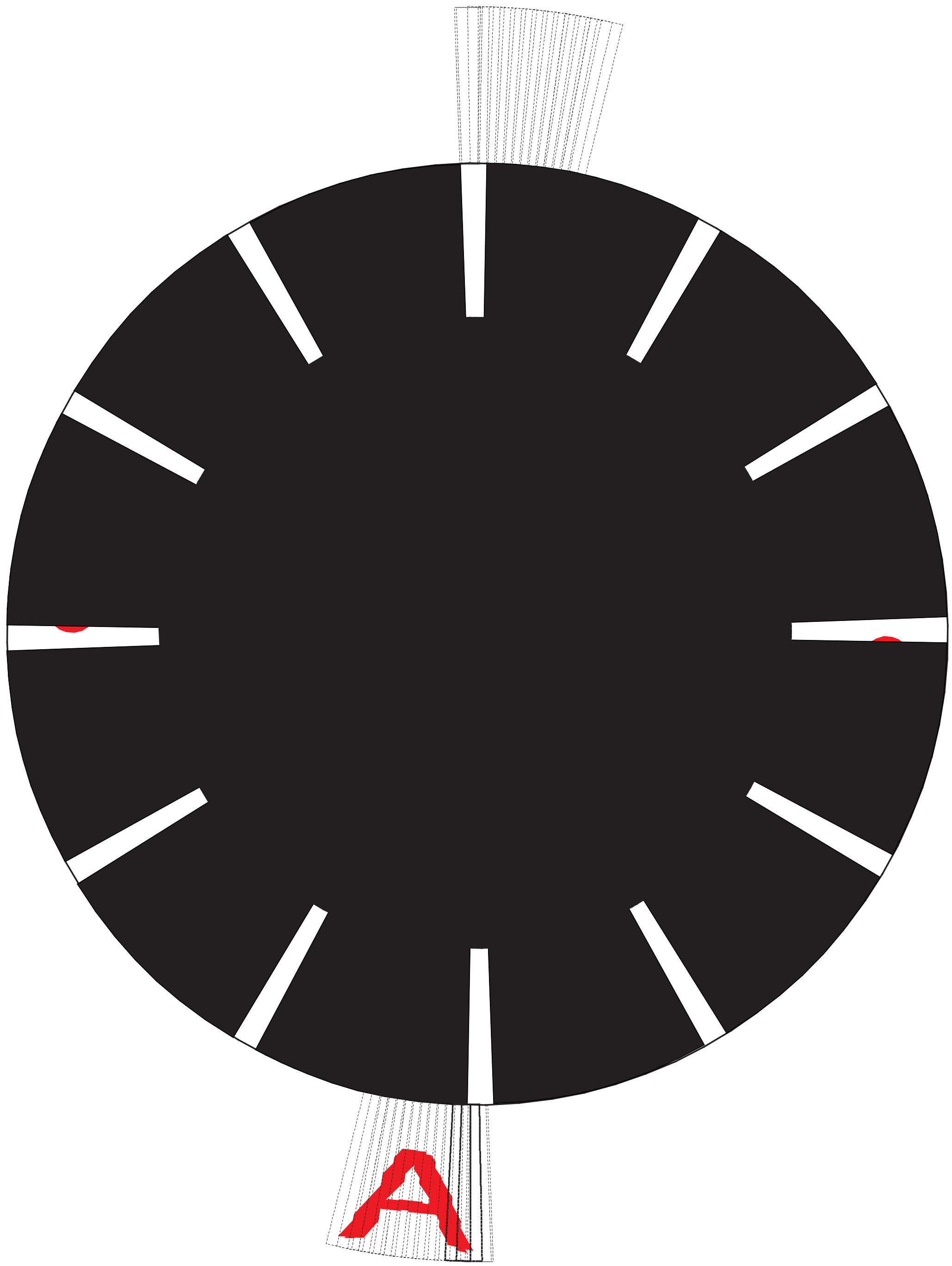

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(without shutter)

