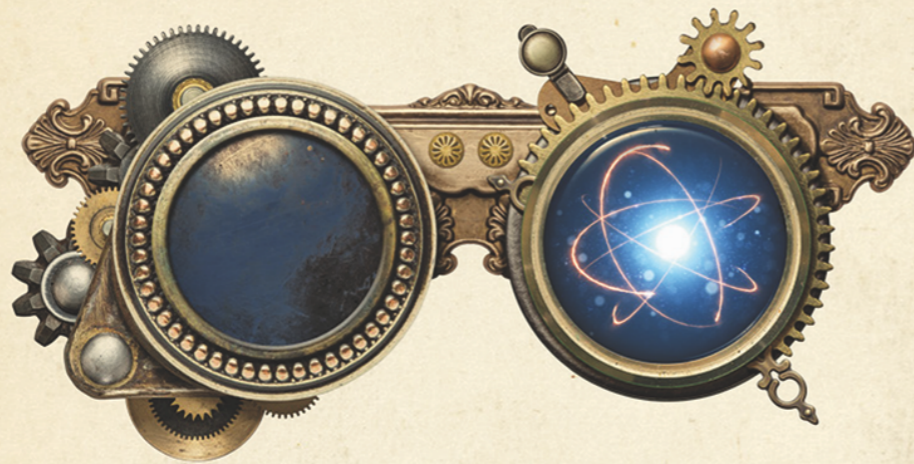


**QUANTUM**



**STEAMPUNK**

**THE PHYSICS OF  
YESTERDAY'S TOMORROW**

**NICOLE YUNGER HALPERN**

**NICOLE YUNGER  
HALPERN**

@nicoleyh11

quantumsteampunk.umiacs.io



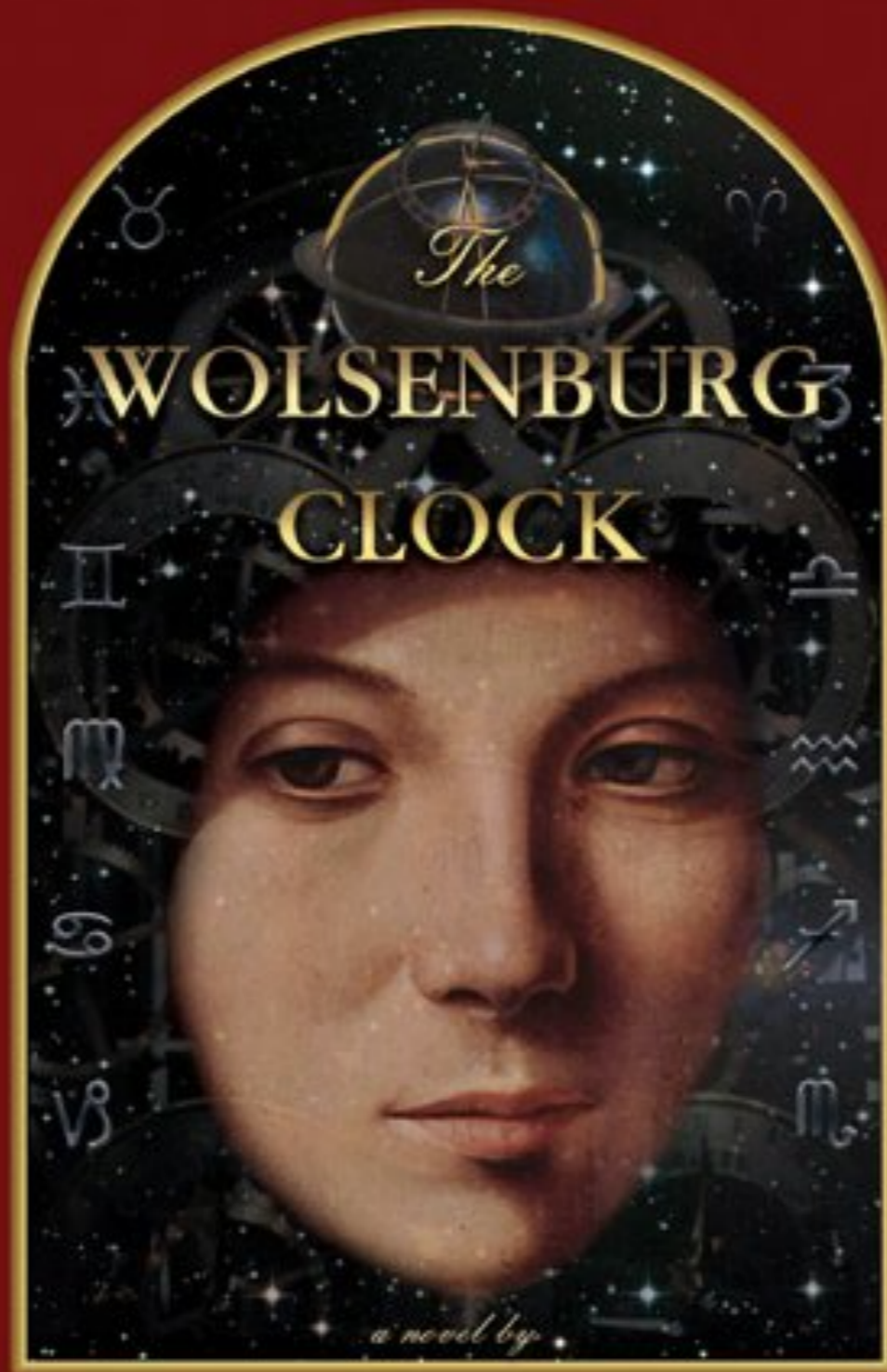


Waterloo, Canada









JAY RUZESKY



# Steampunk





# Steampunk







# Steampunk





“Steampunk is a genre that imagines how different the past might have been, had the future come earlier.”

-Douglas Fetherling



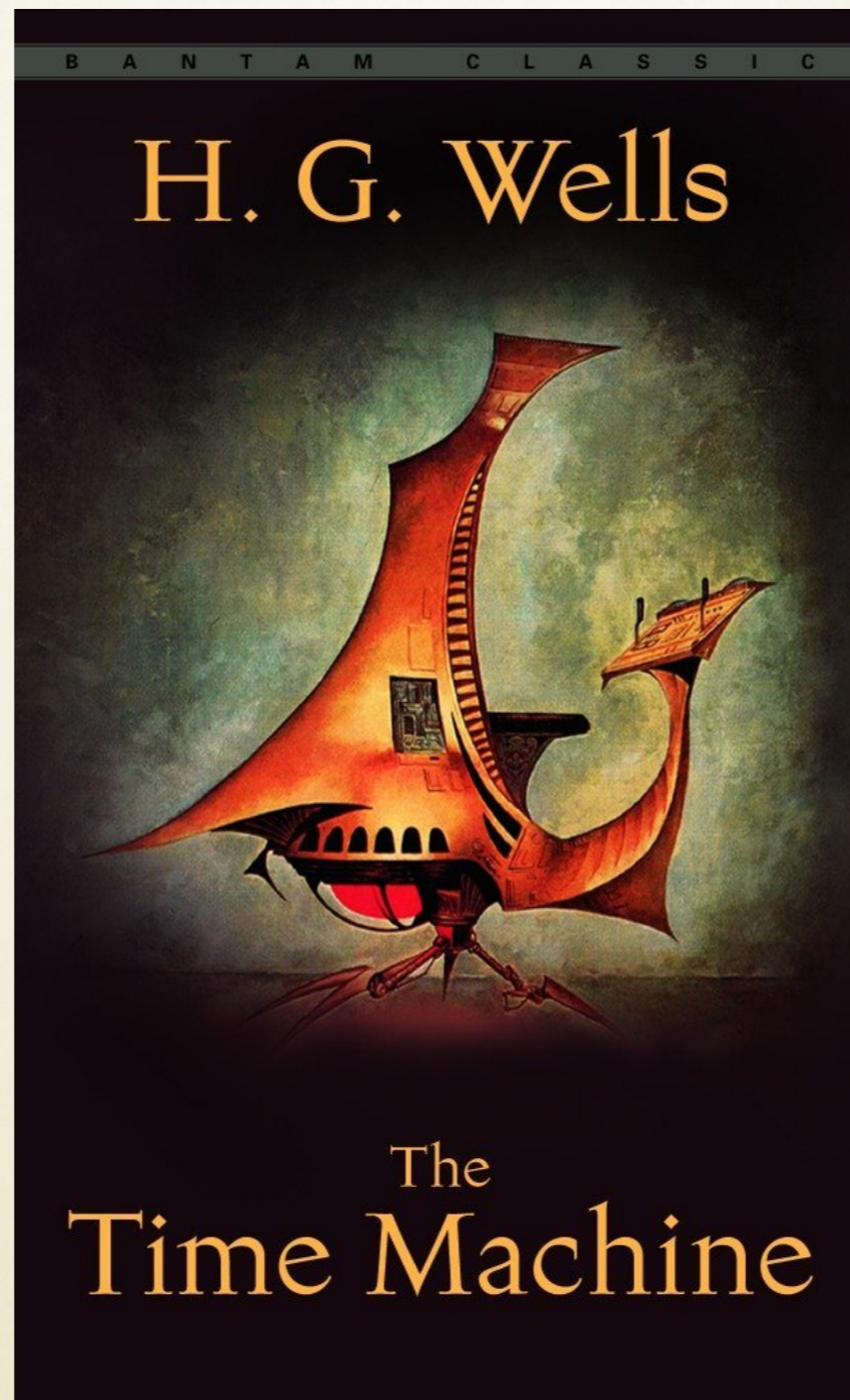
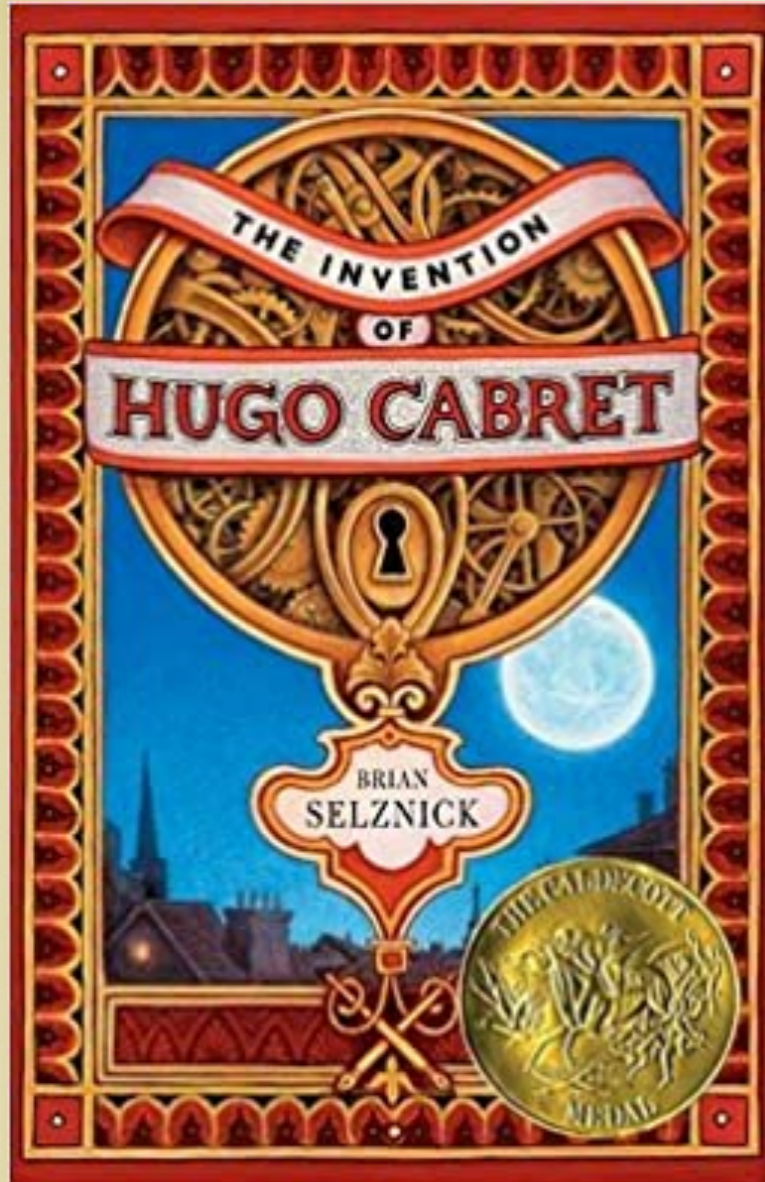
B A N T A M C L A S S I C

H. G. Wells

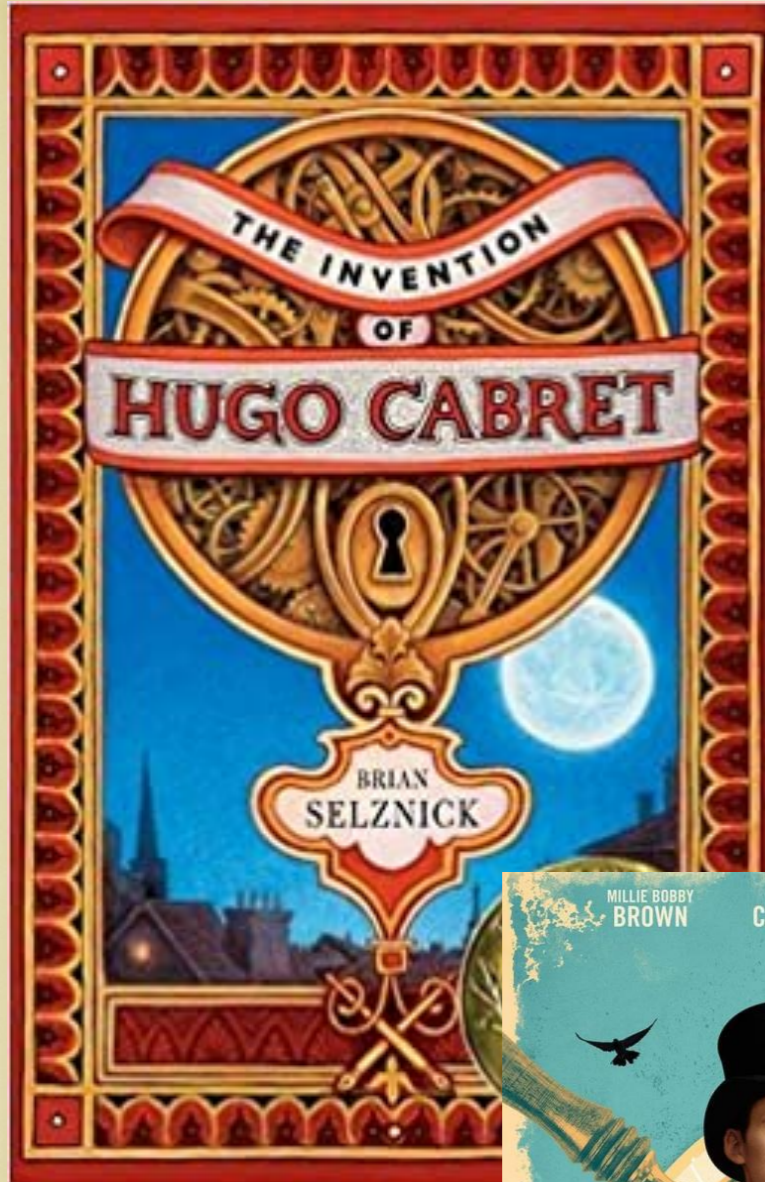


The  
Time Machine

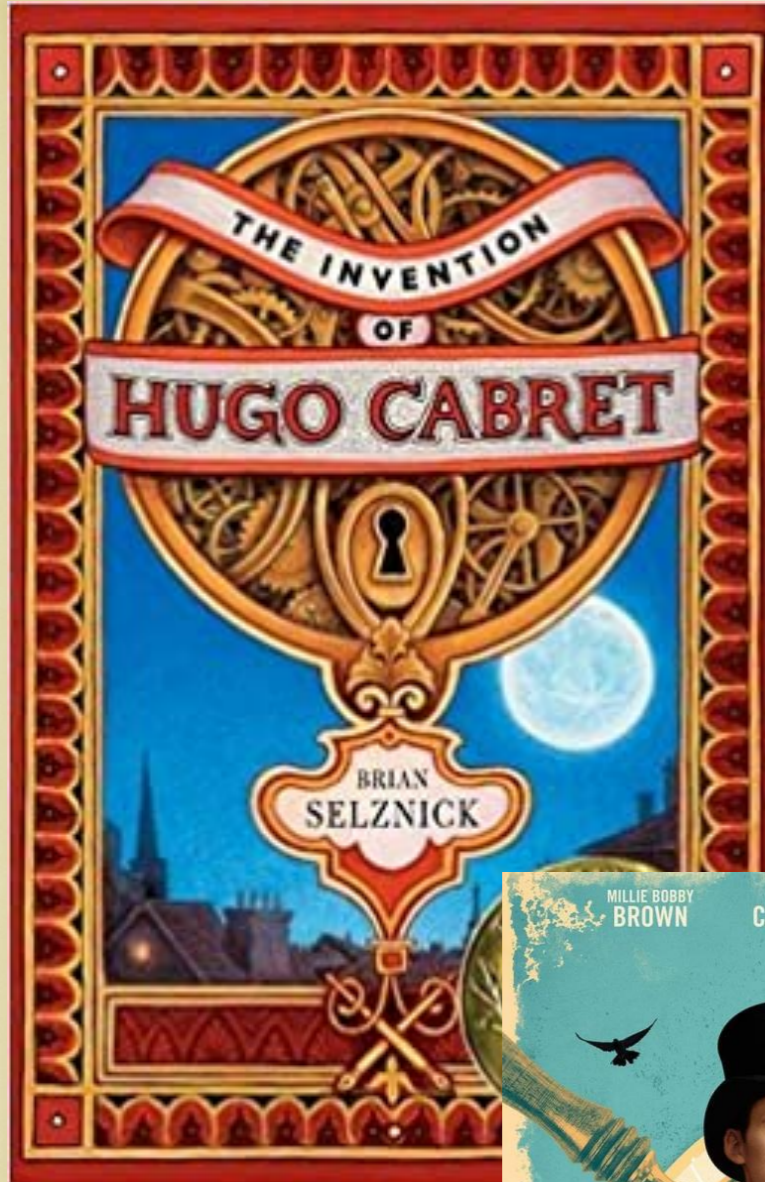




















The fantasy  
has become reality.





$$D_\alpha(R|S) := \begin{cases} \frac{\text{sgn}(\alpha)}{\alpha-1} \log \left( \sum_{j=1}^d r_j^\alpha s_j^{1-\alpha} \right) & \alpha \in (0, 1) \\ \lim_{\alpha \rightarrow 1} D_\alpha(R|S) & \alpha \in (1, \infty) \end{cases}$$

↑ analogous  $\alpha=0, \infty$

$$W = \int_{V_i}^{V_f} p dV$$

$$pV = \underbrace{N}_{=1} k_B T \quad \therefore p = \frac{k_B T}{V}$$

$$W = \int_{V/2}^V \frac{k_B T}{V} dV = k_B T \ln|V| \Big|_{V/2}^V$$

$$\boxed{W = k_B T \ln 2}$$

B)  $P_{\text{fwd}}(W)$

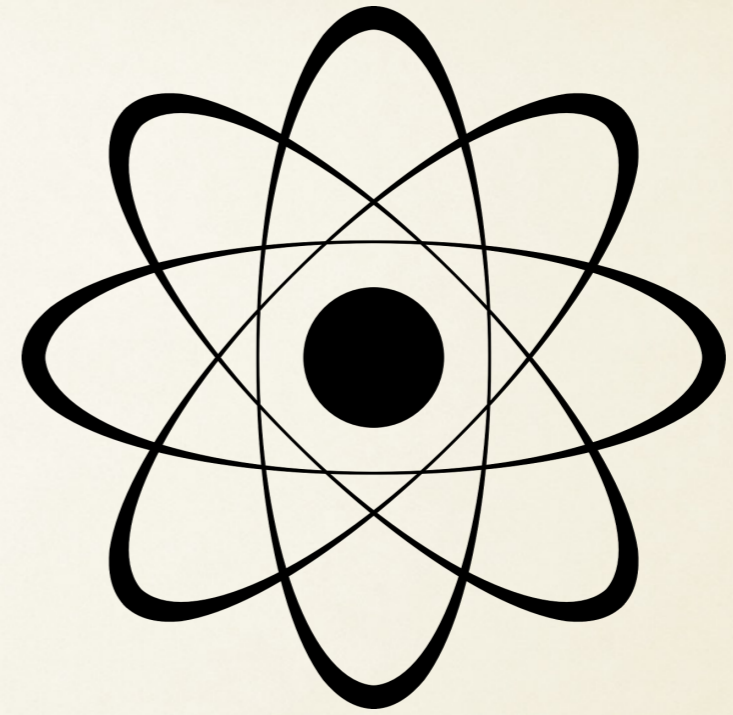
$$P_{\text{fwd}}(W) = \sum_{j,k: E'_k - E_j = W} p(E_j) p(E'_k | E_j)$$

$$\sum_{j,k} \Theta(E'_k - E_j - W) \frac{e^{-\beta E_j}}{Z}$$

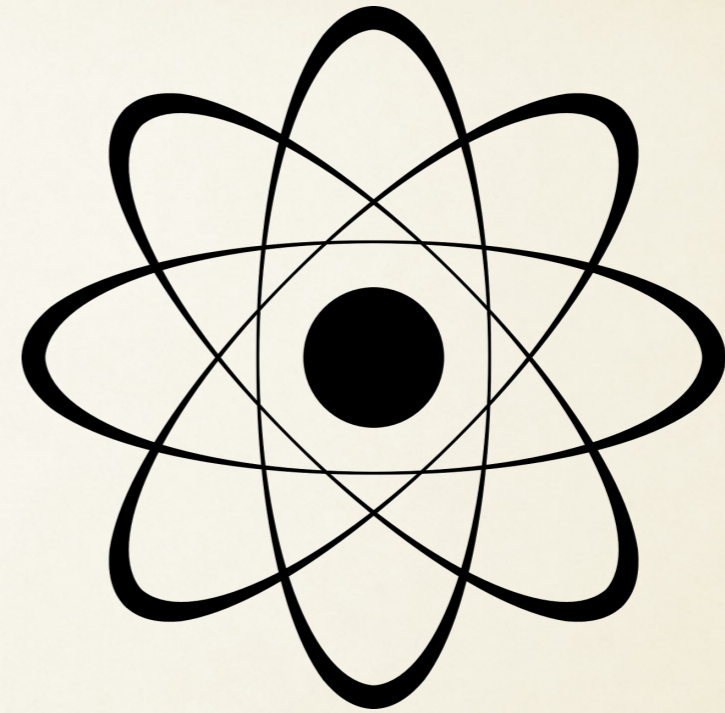
$|\langle E'_k | U | E_j \rangle|^2$   
 $\langle E'_k | U | E_j \rangle$   
 $\times \langle E_j | U^\dagger | E'_k \rangle$   
 $\text{Tr}(|E'_k \rangle \langle E'_k| U | E_j \rangle \langle E_j| U^\dagger)$

$$= \sum_{j,k} \Theta(E'_k - E_j - W) \frac{e^{-\beta E_j}}{Z} \text{Tr}(|E'_k \rangle \langle E'_k| U | E_j \rangle \langle E_j| U^\dagger)$$

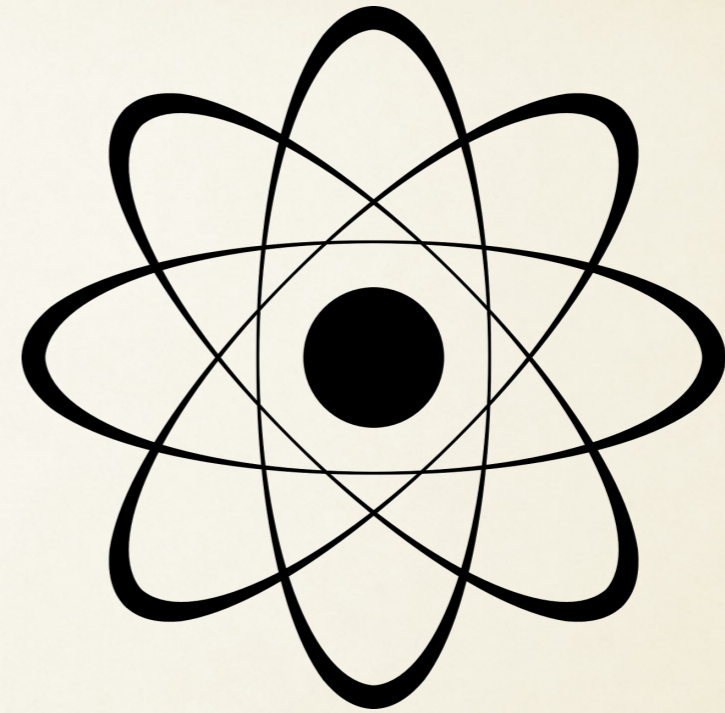




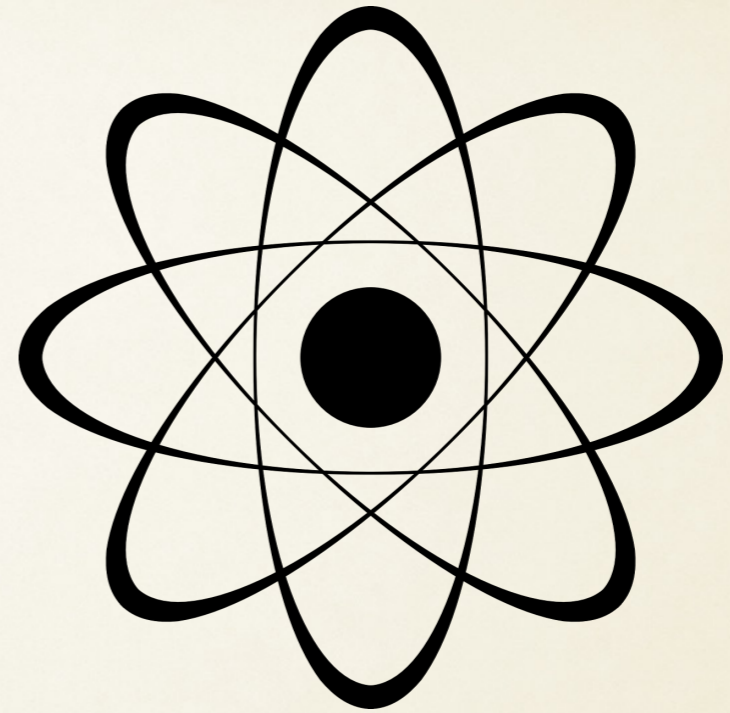




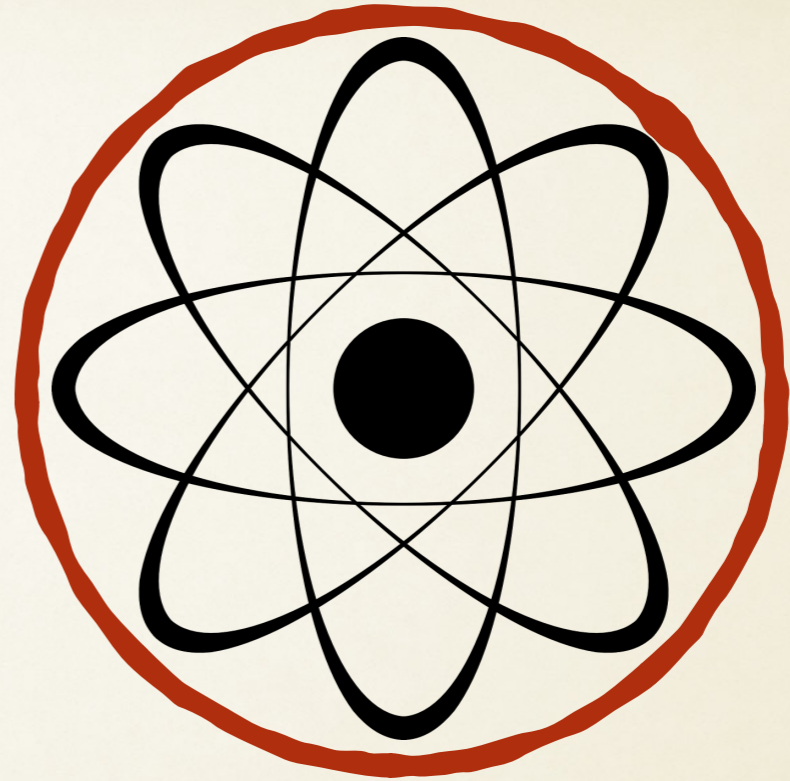




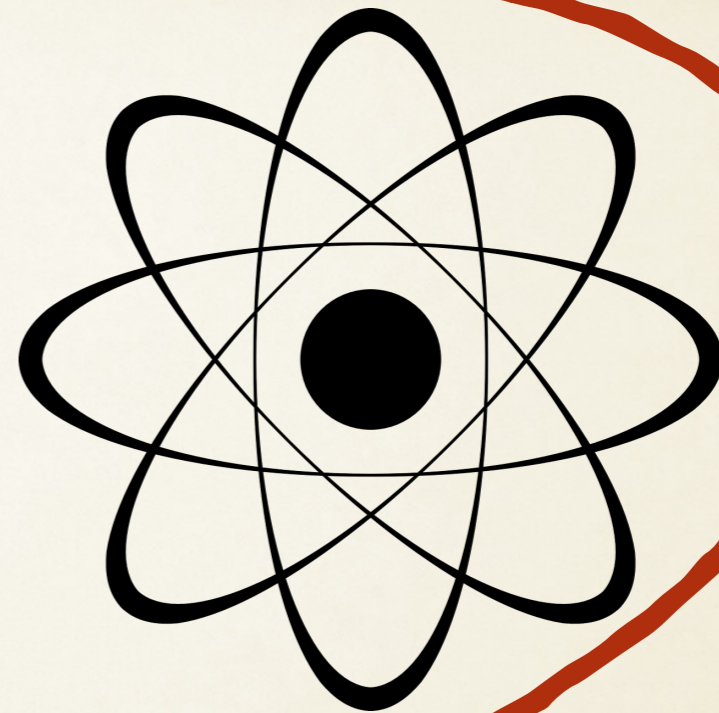




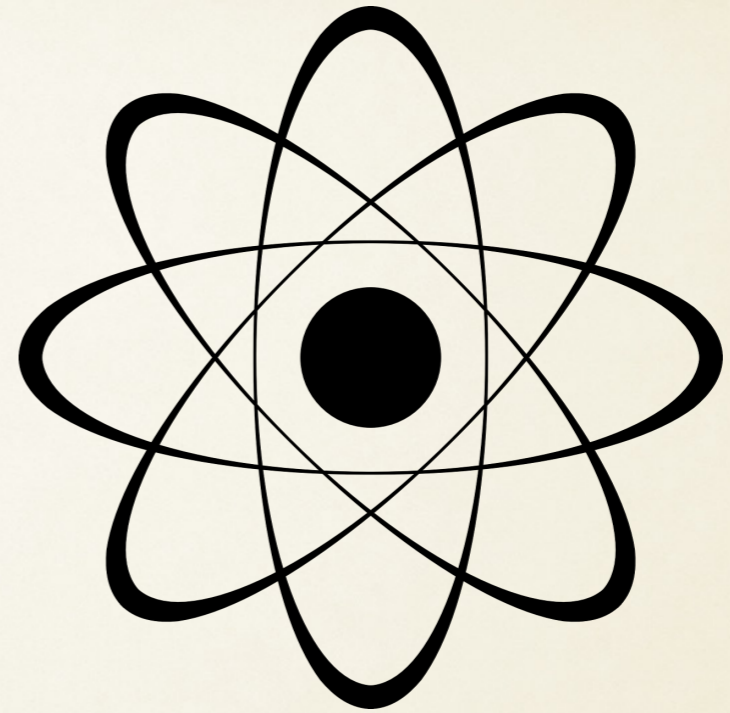




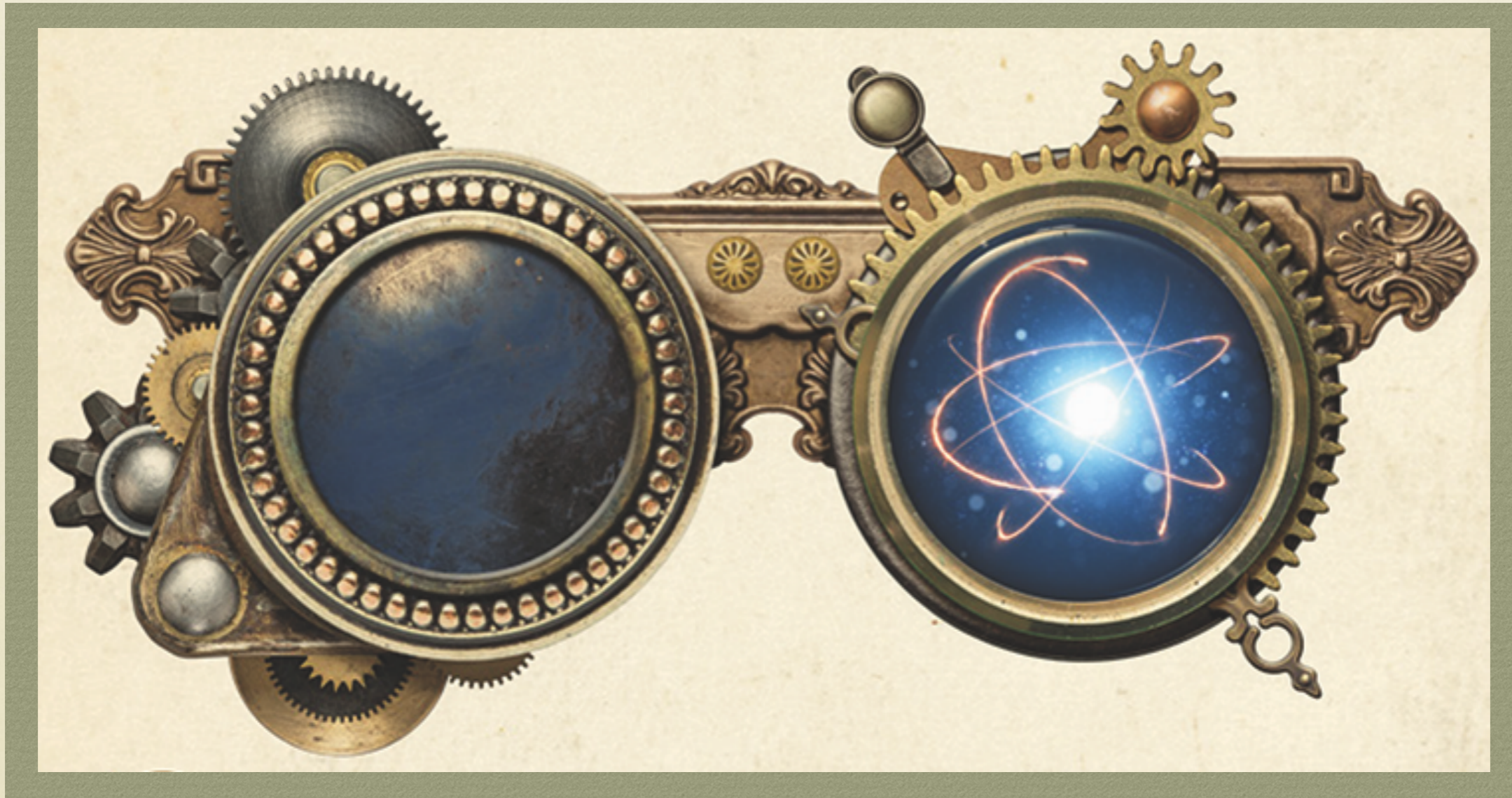










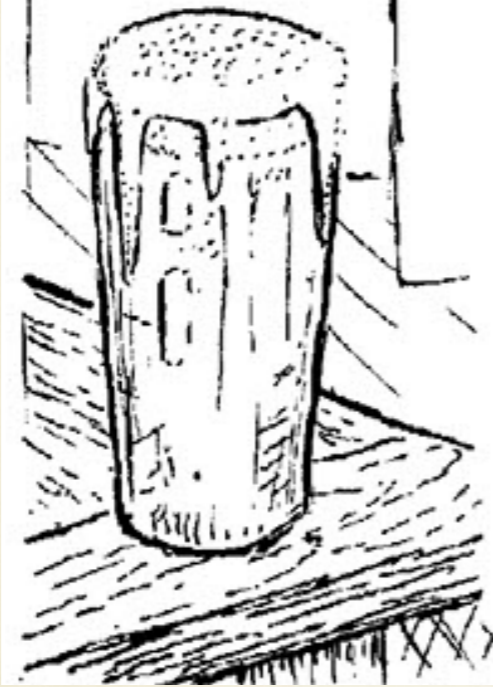




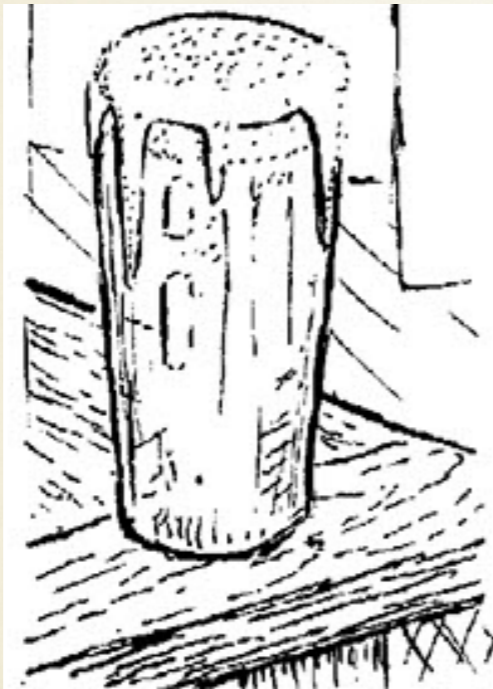
# Information science



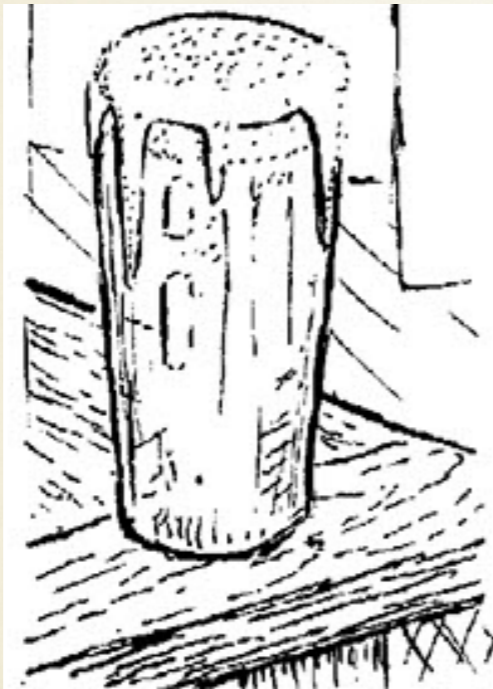












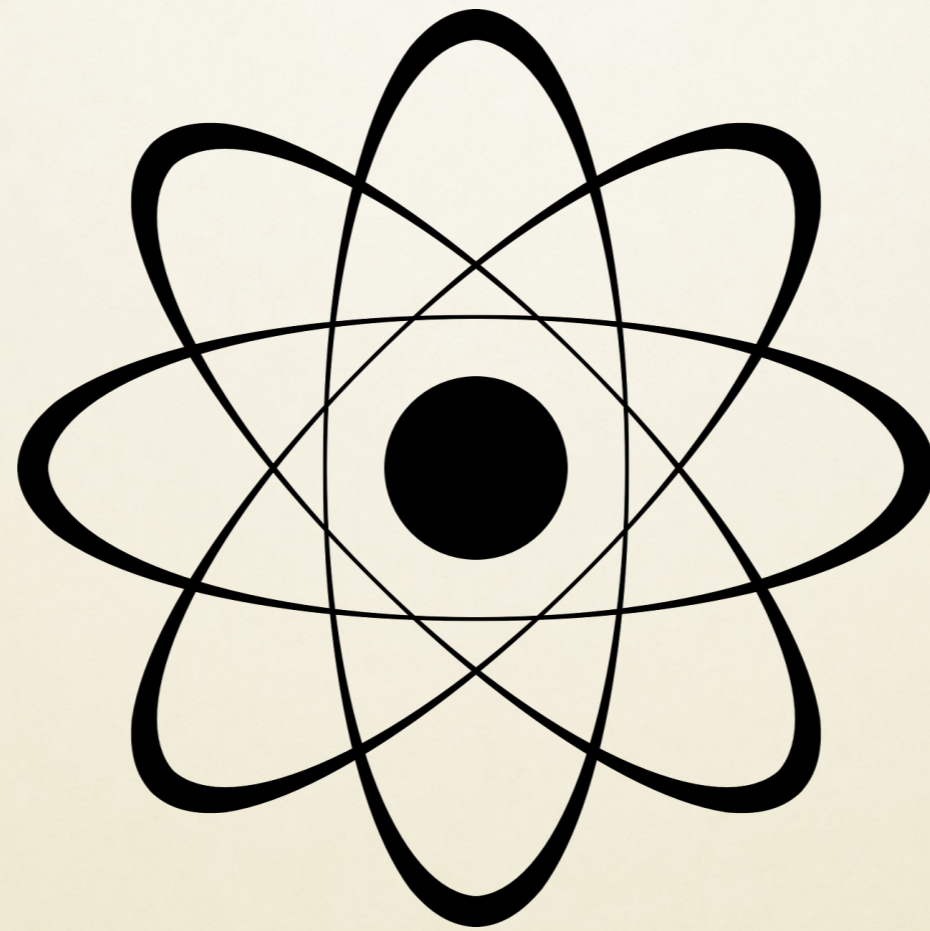
↑  
 $1/2$



↑  
 $1/2$

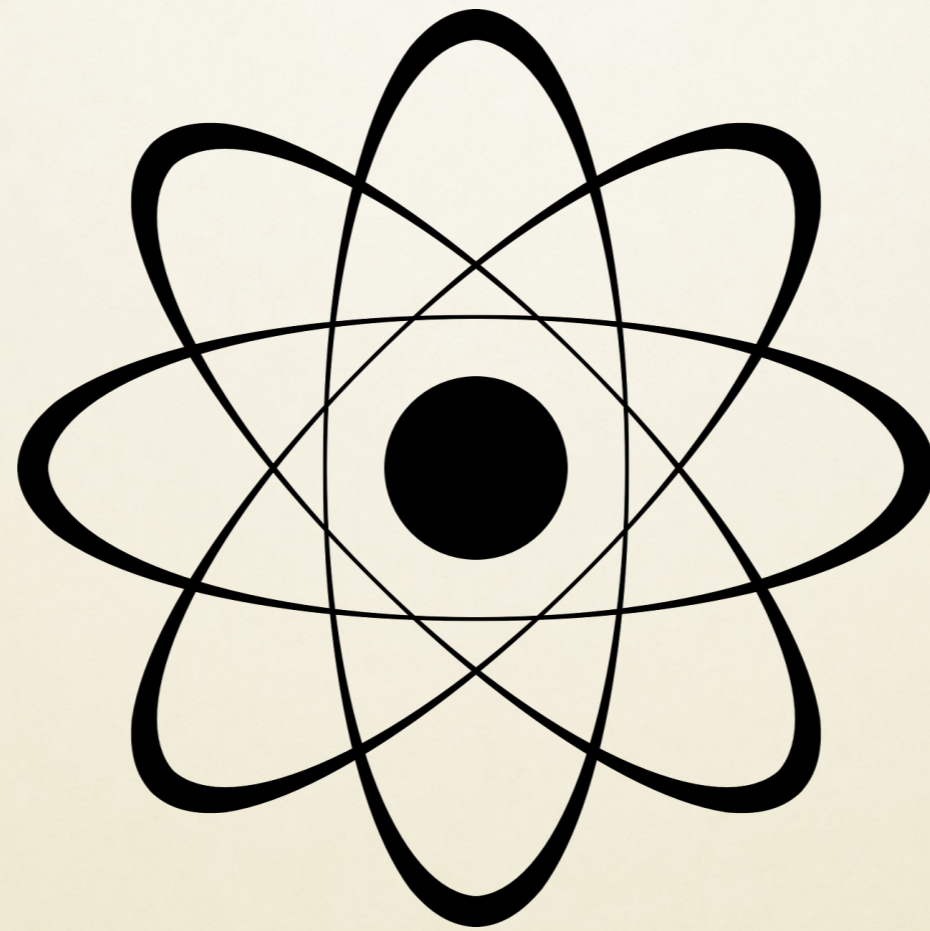


# Quantum physics

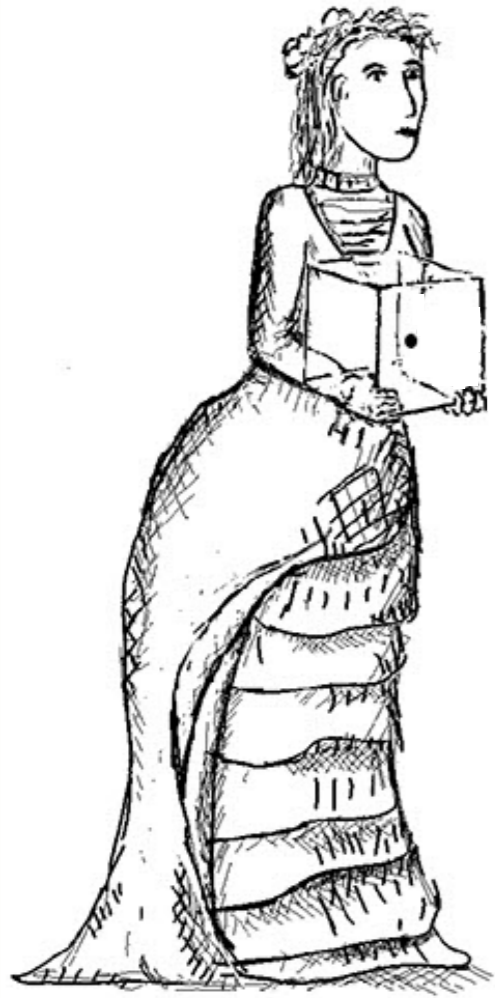




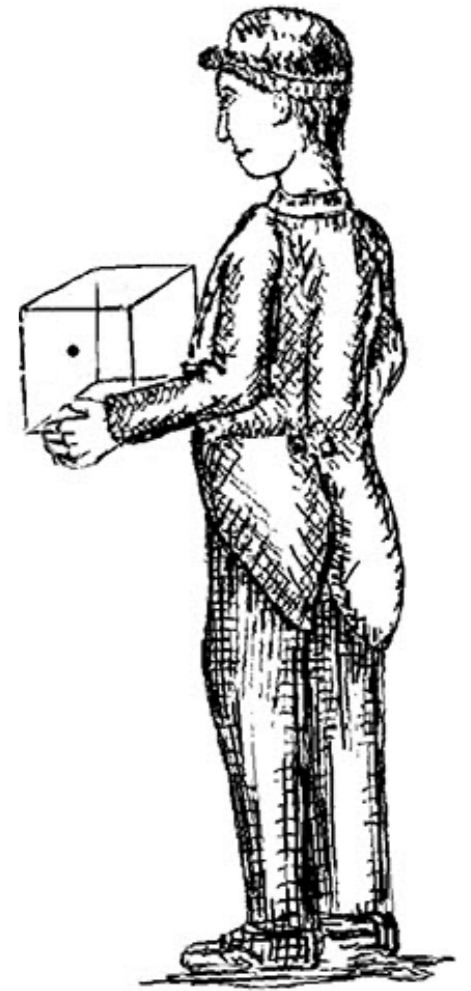
# Quantum (nonclassical) physics







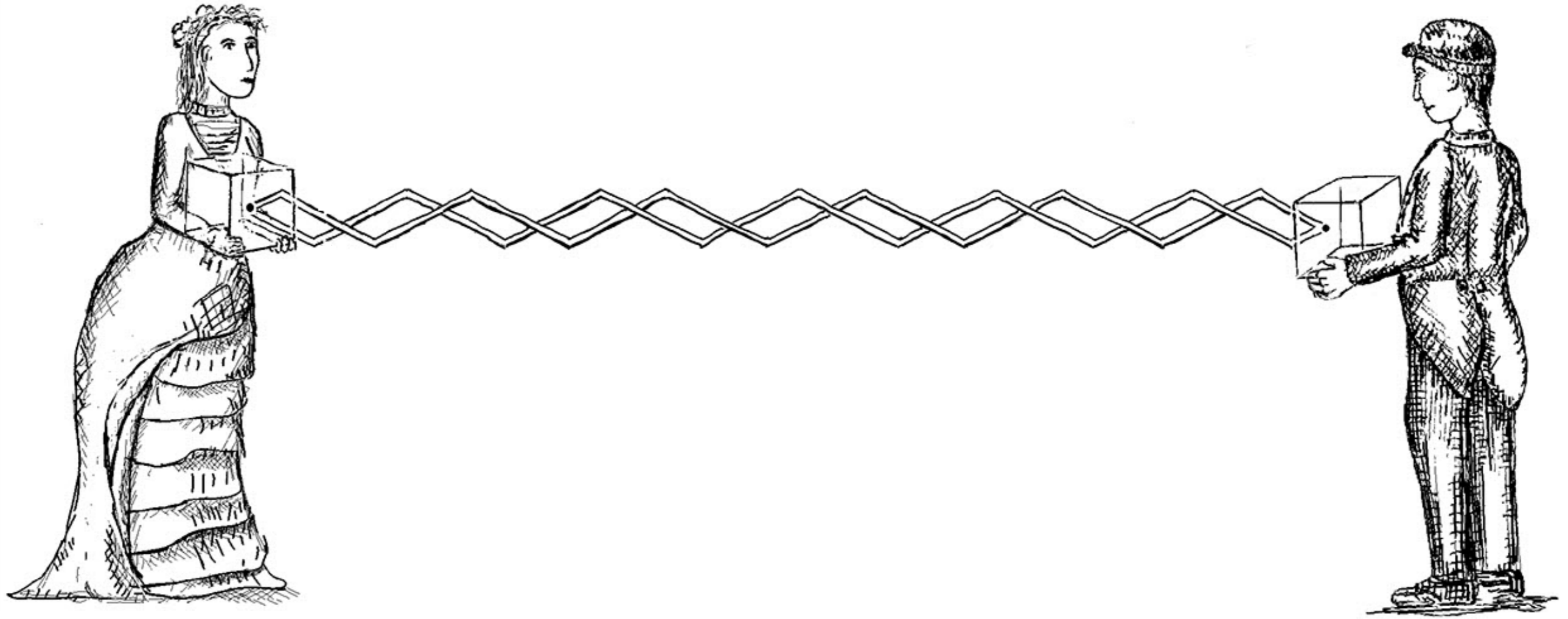
Audrey



Baxter



# Entanglement

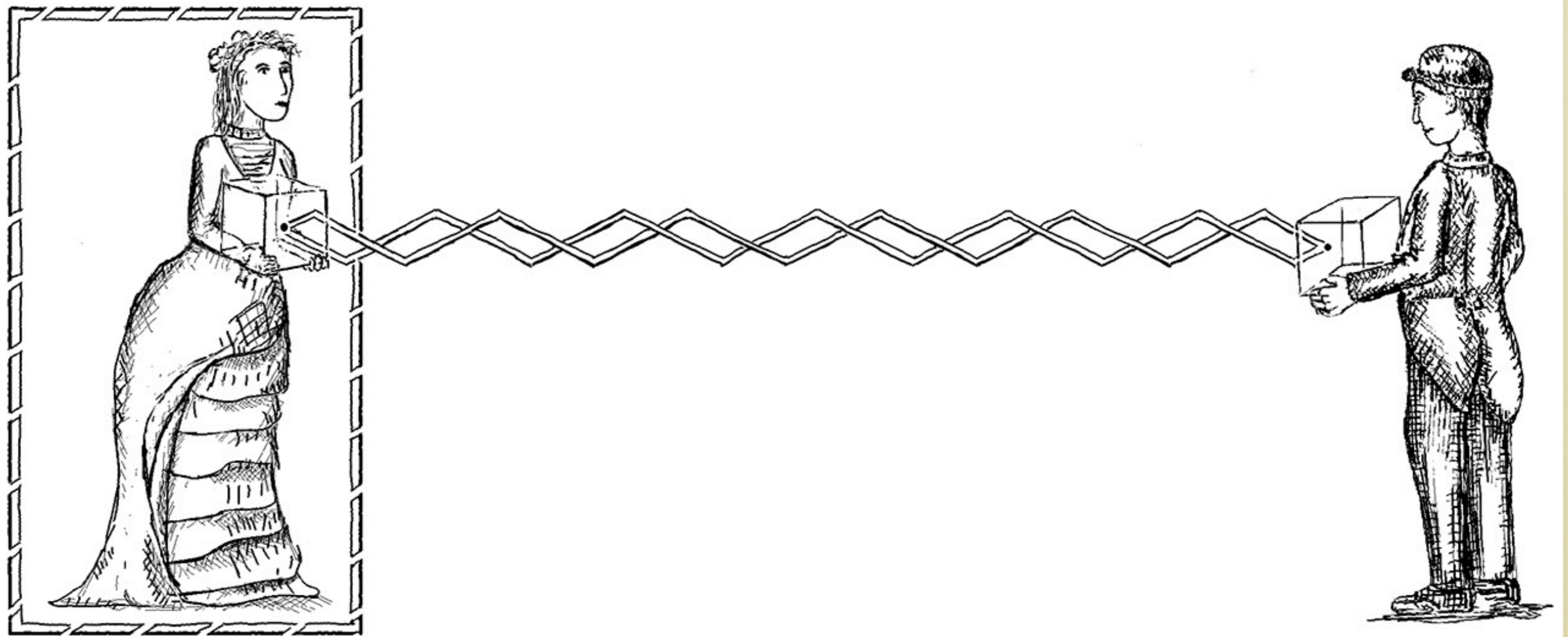


Audrey

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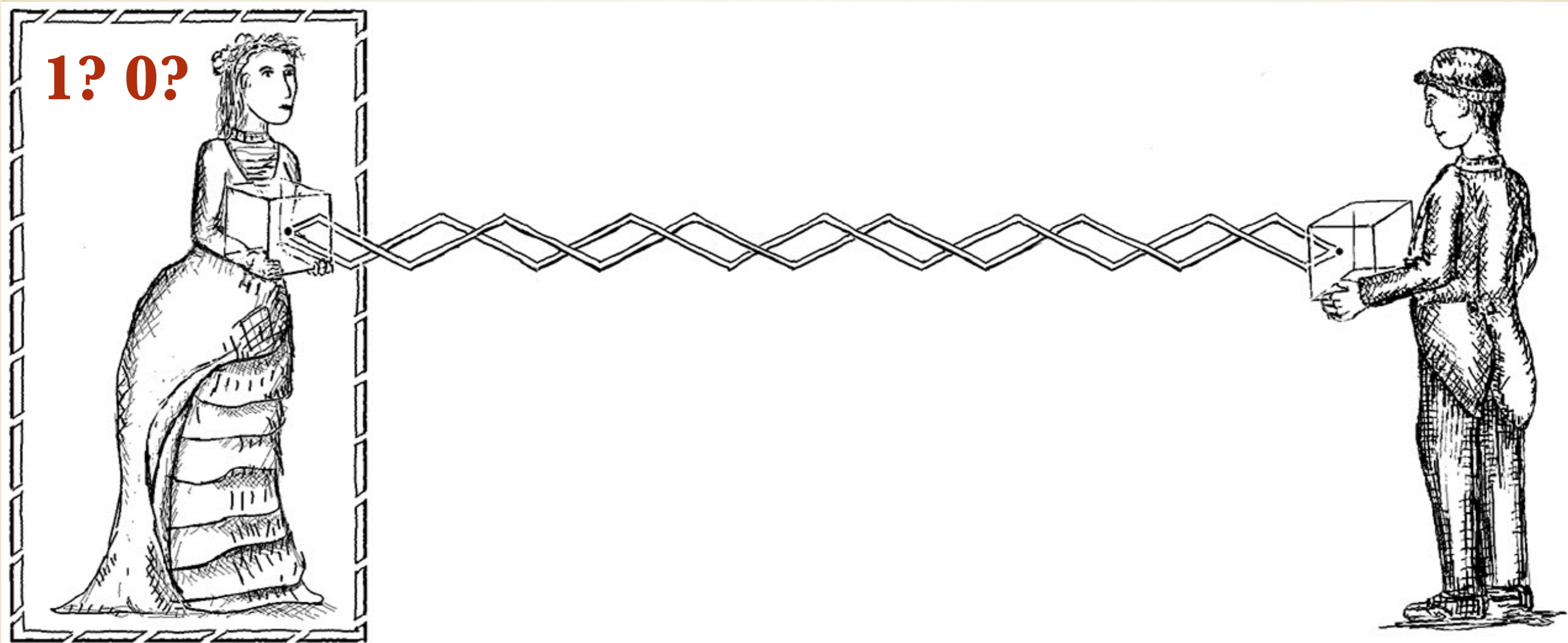


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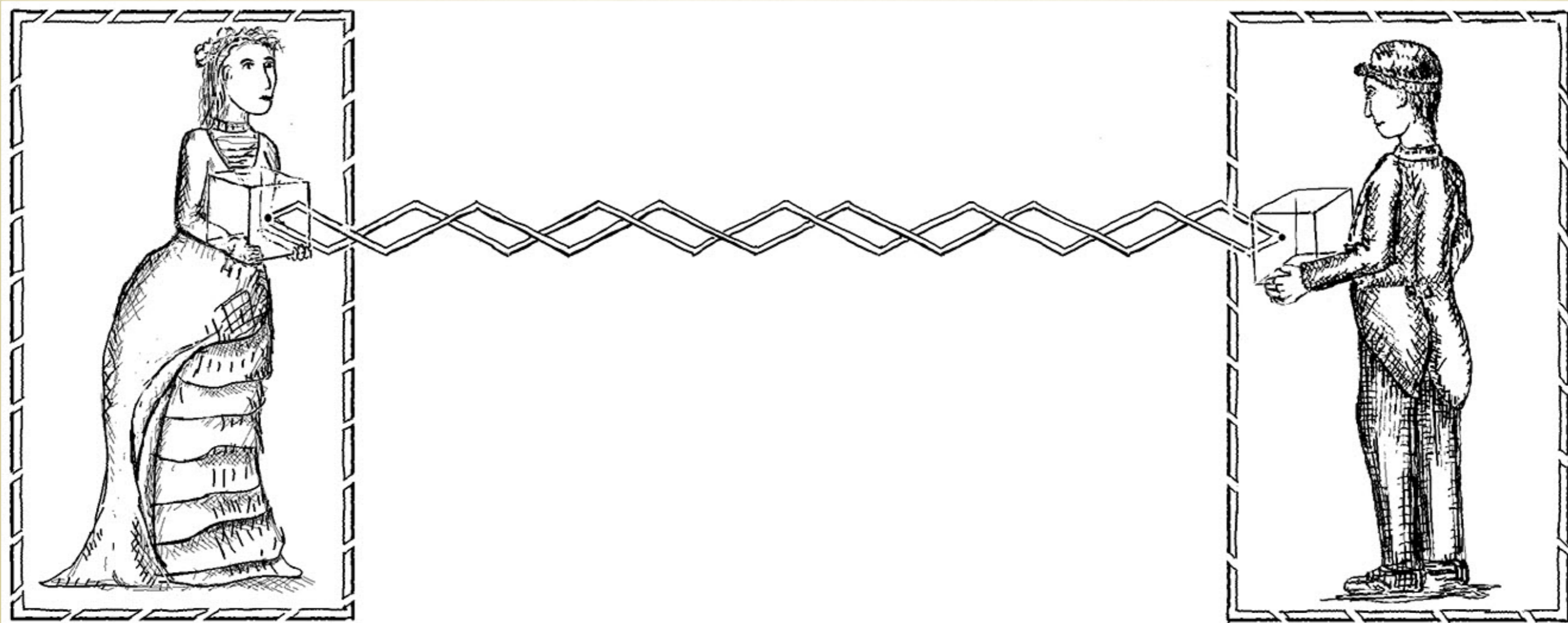


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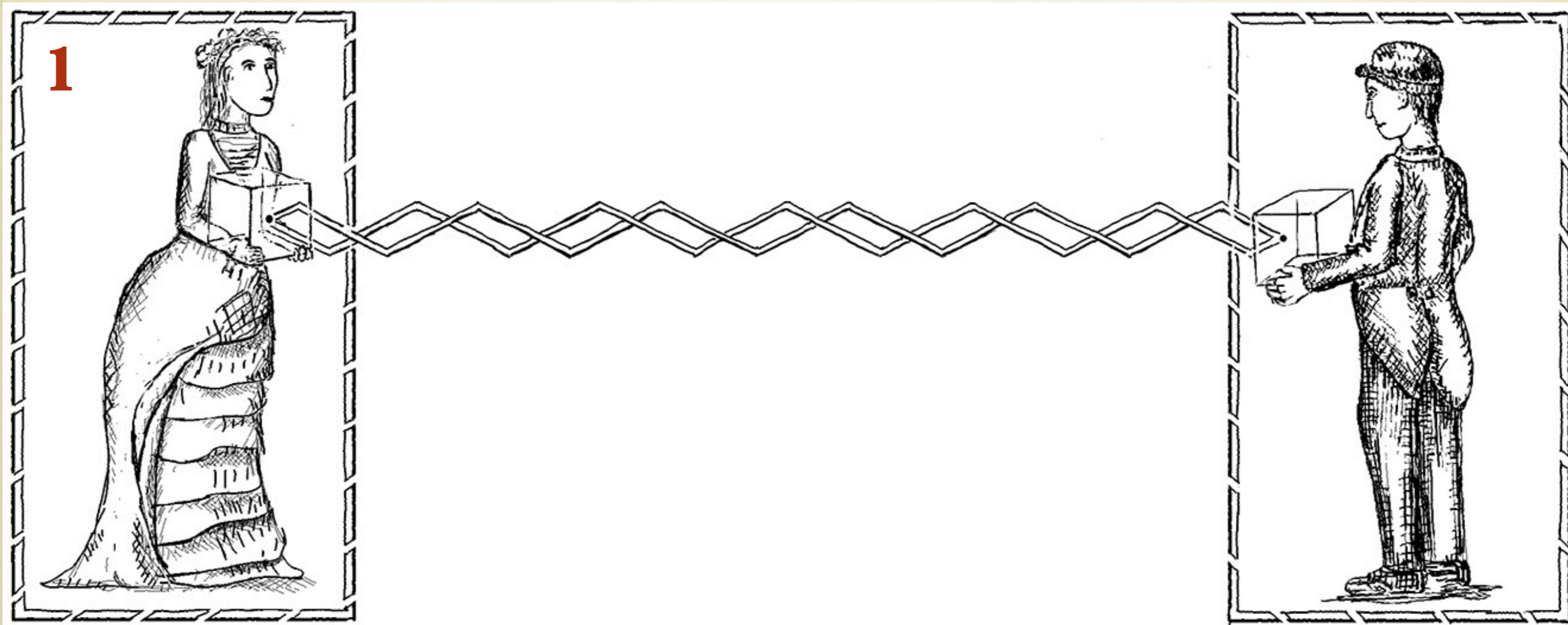


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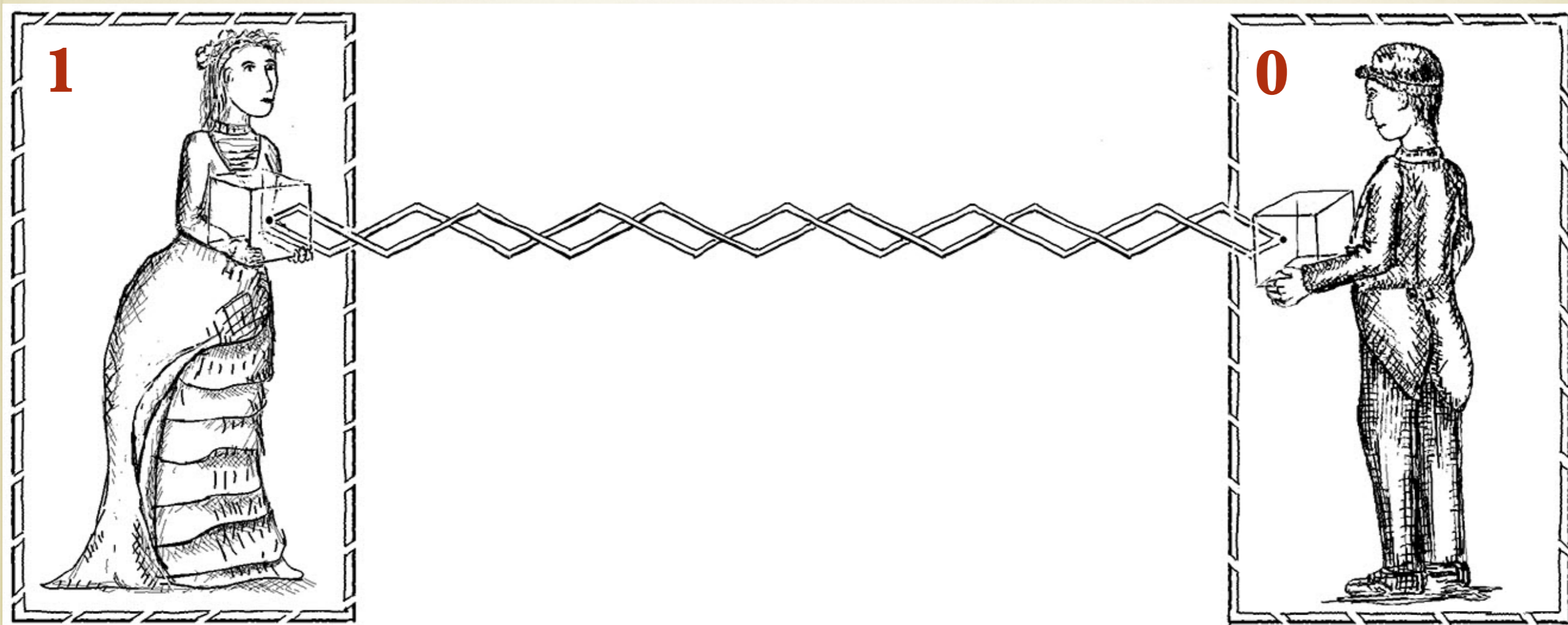


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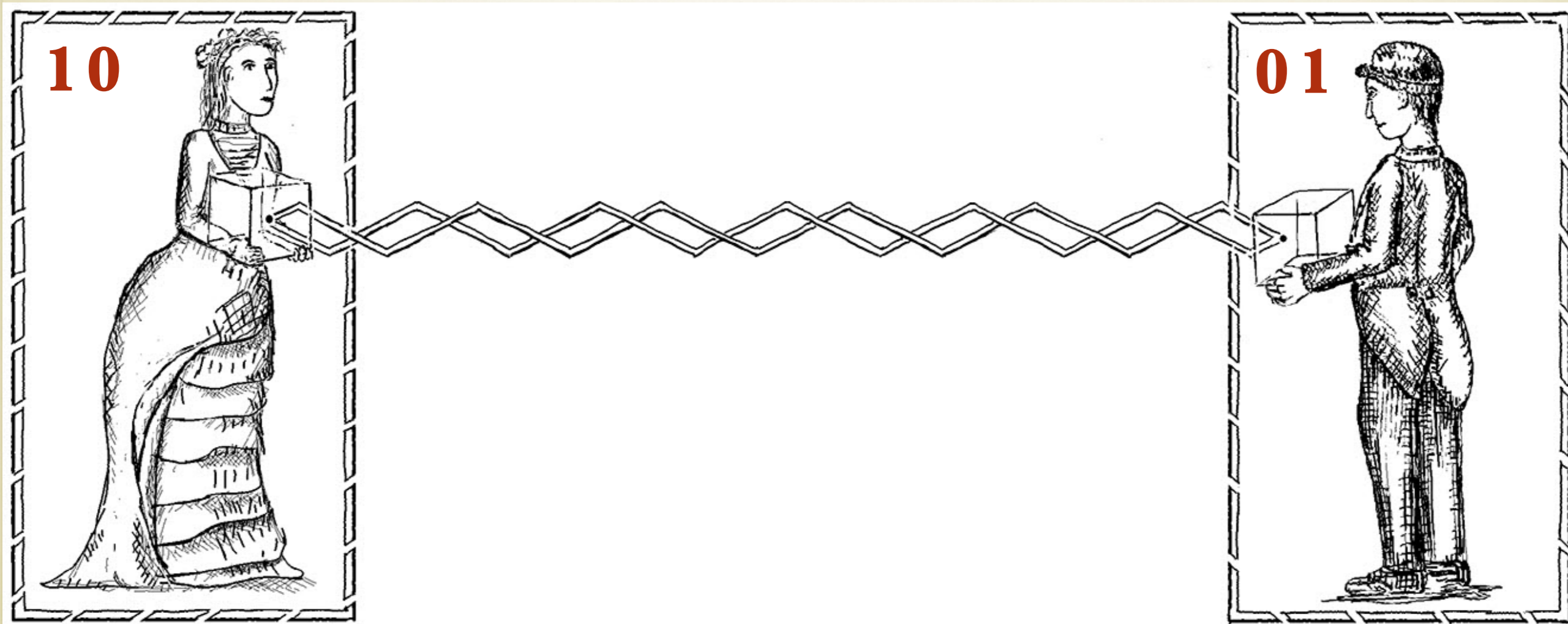


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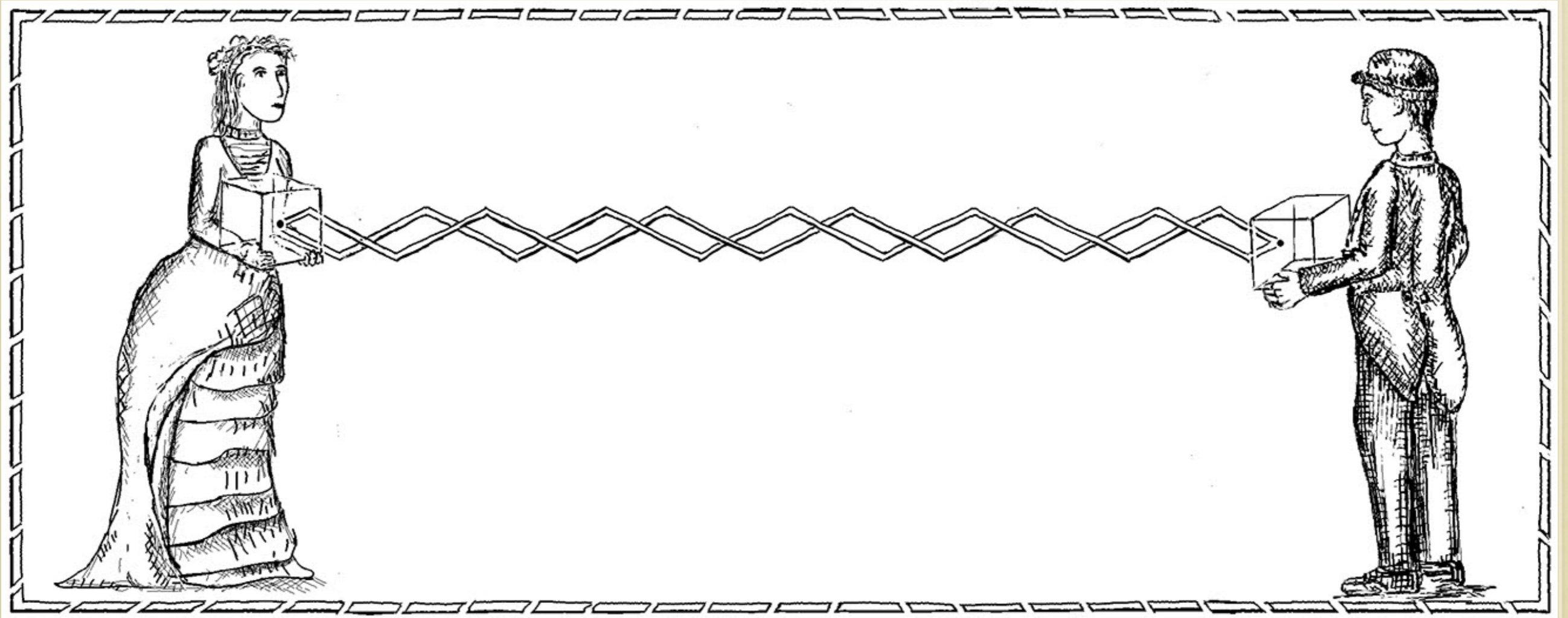


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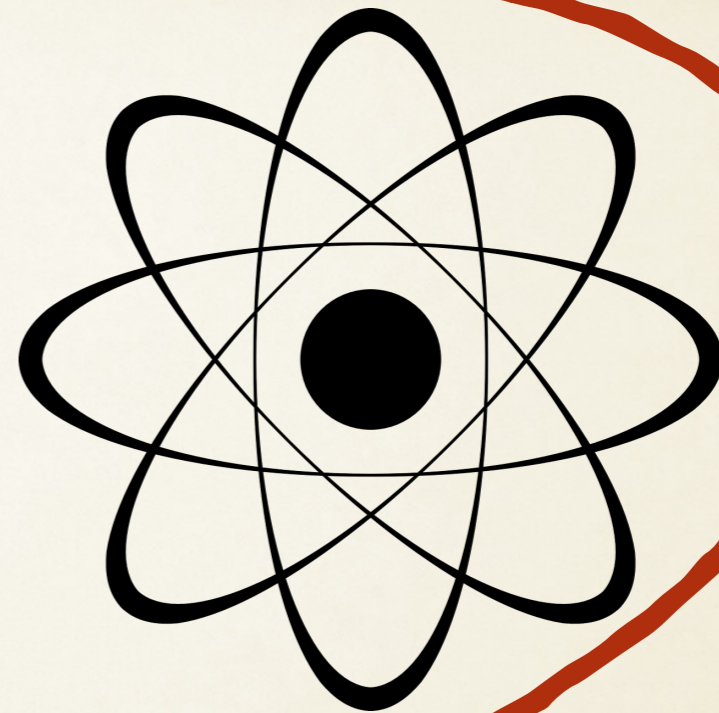




# Entanglement



















[quantum.gov](https://quantum.gov)



# Microsoft Quantum

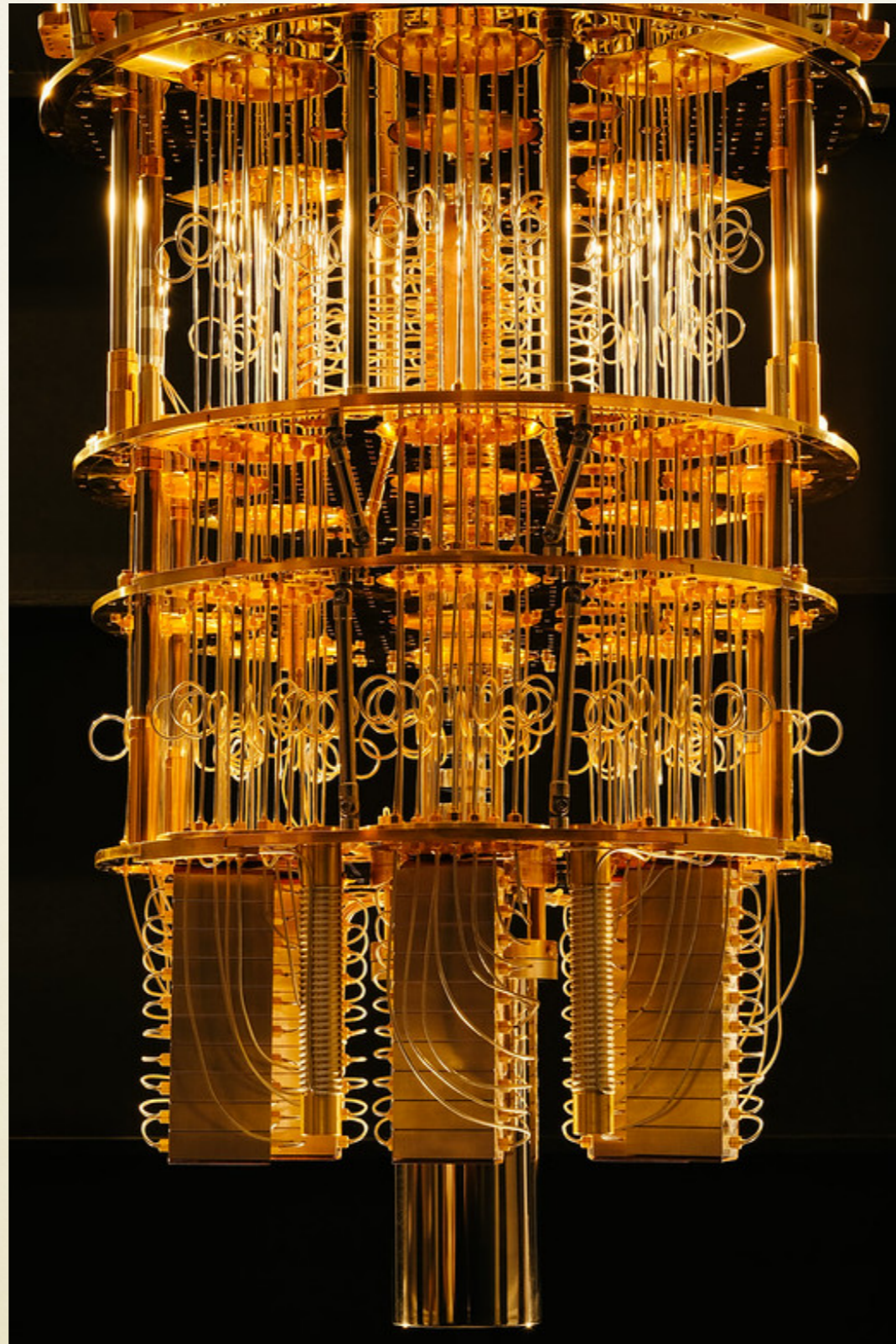
Get to know the world's first full-stack, open cloud quantum computing ecosystem





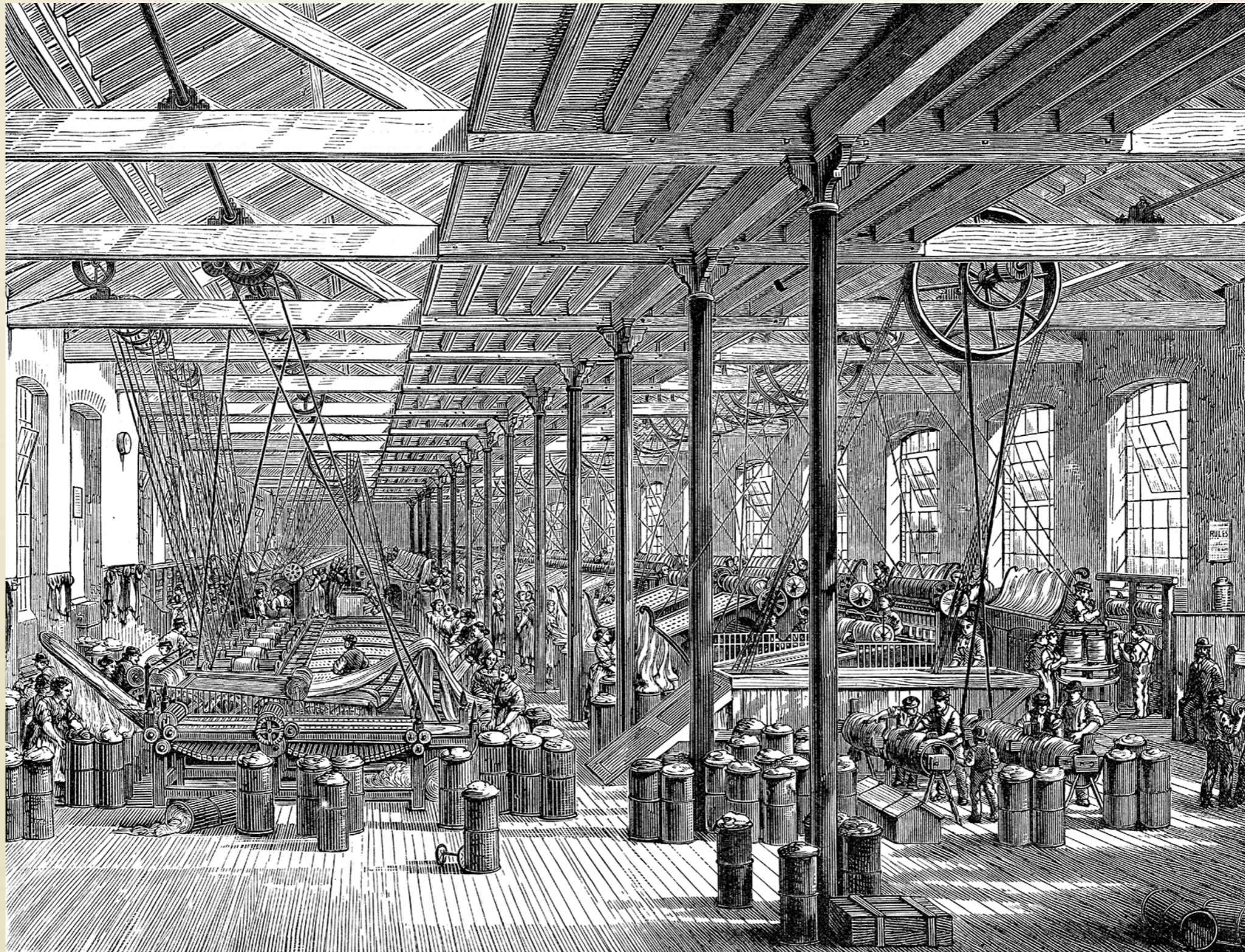




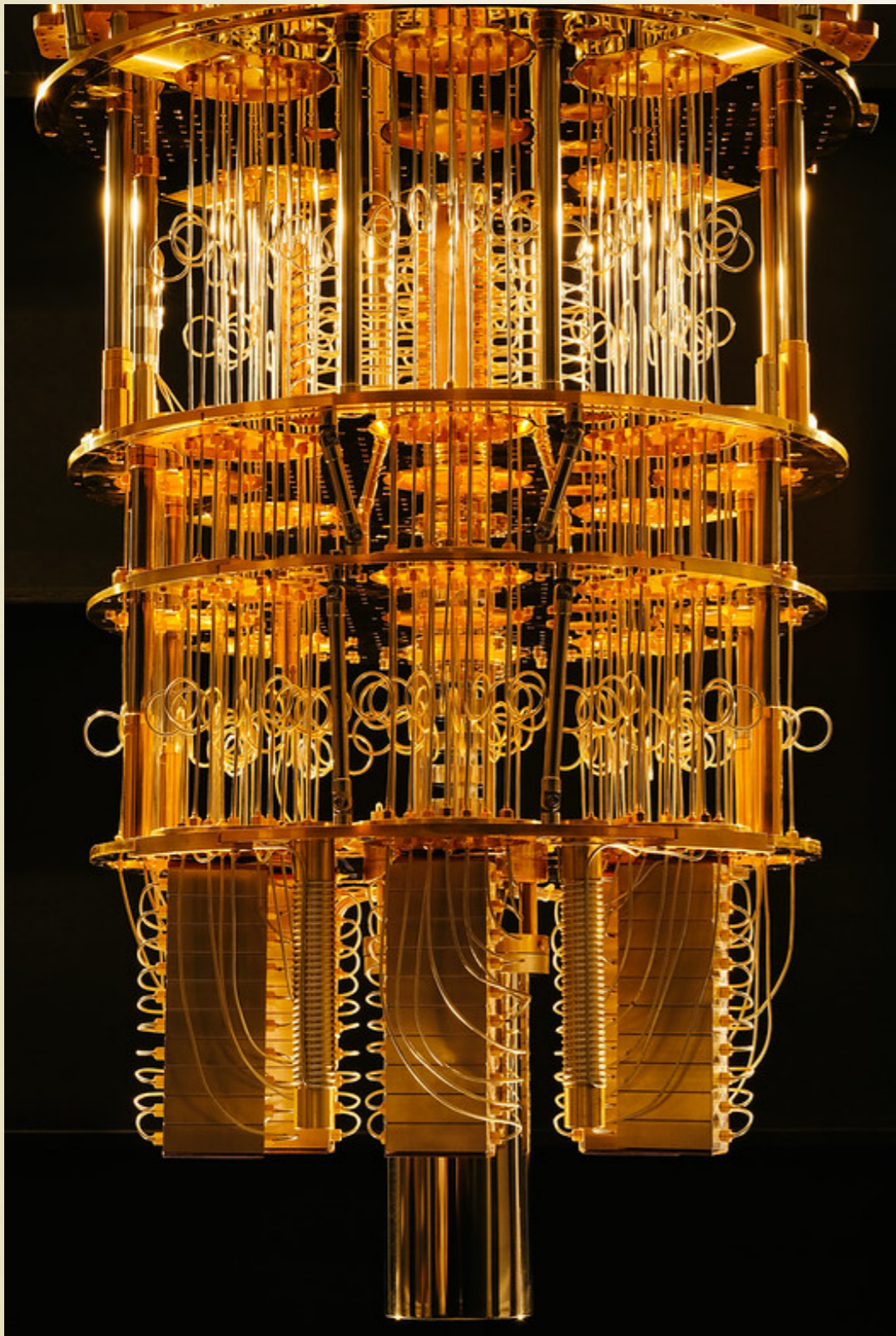




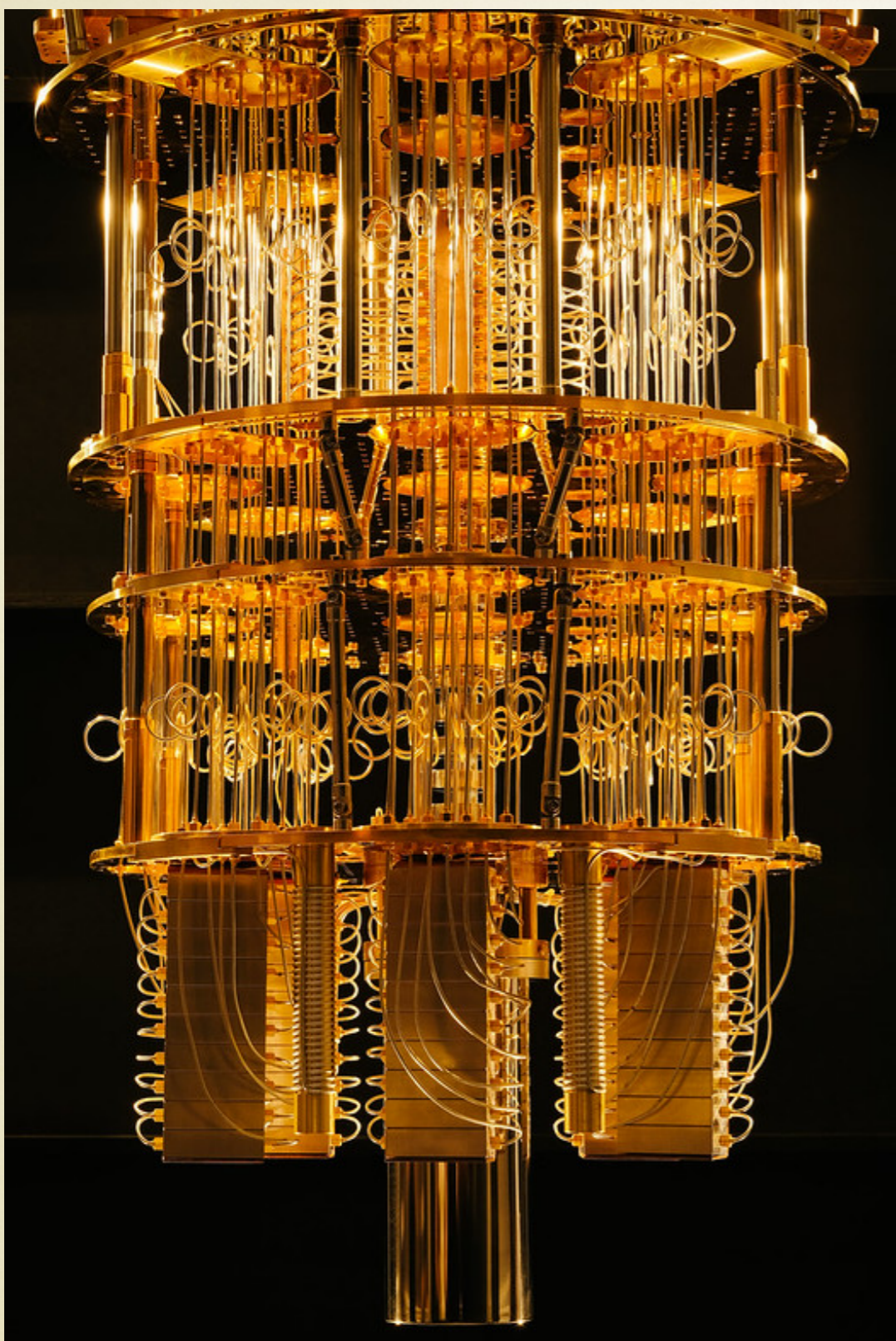
# Thermodynamics





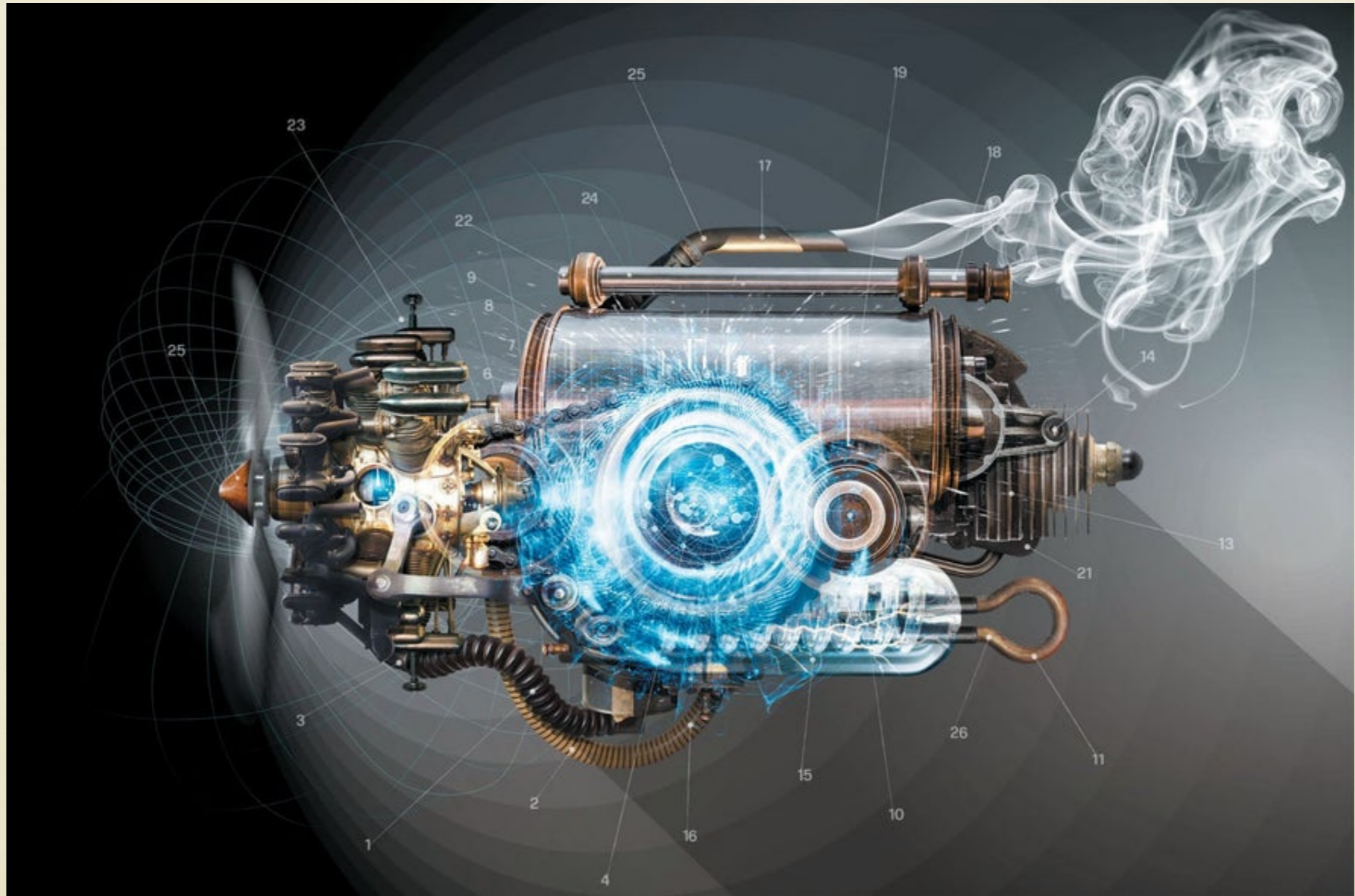






Werner Heisenberg





Victor Koen (*Scientific American*, 2020)

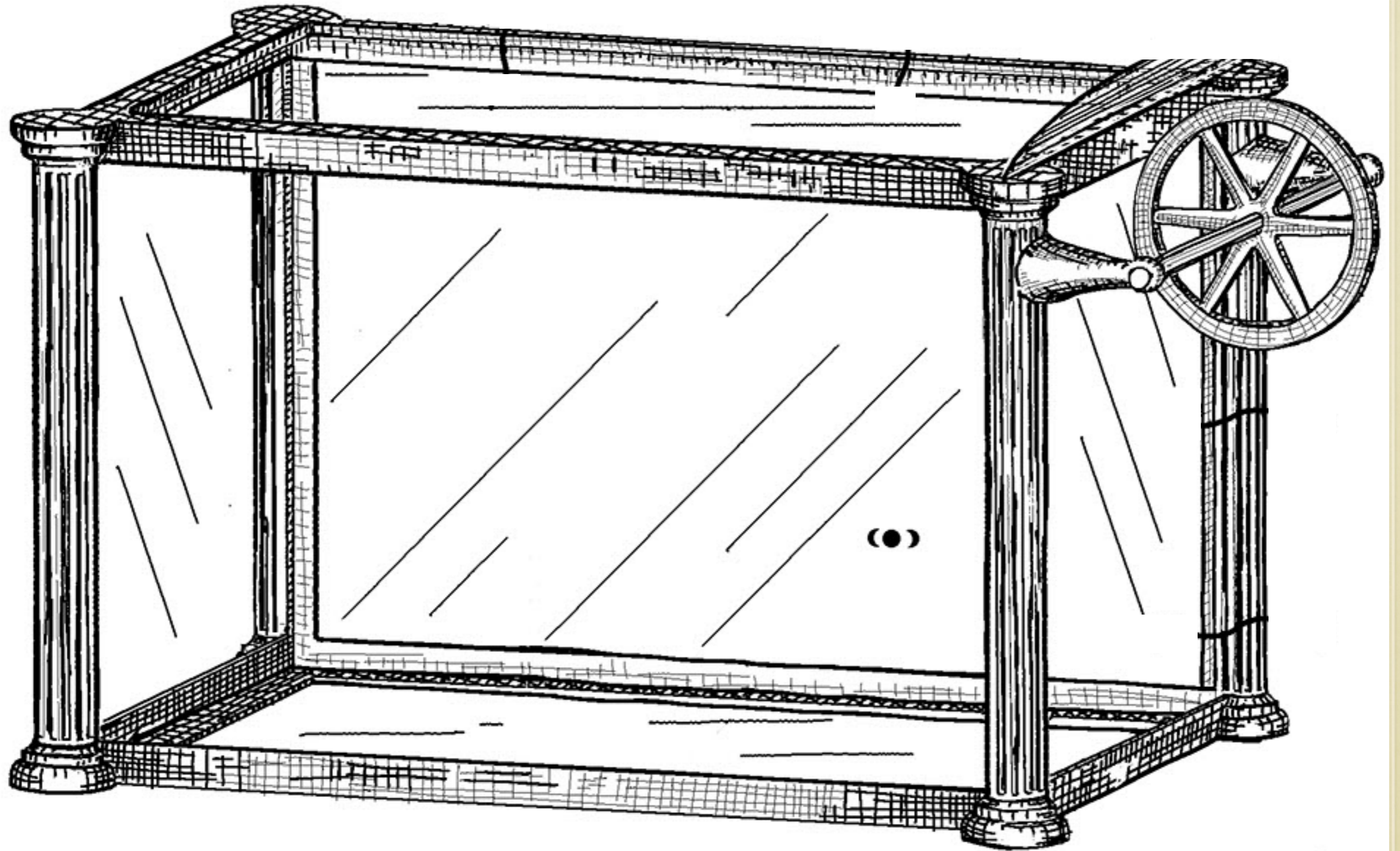




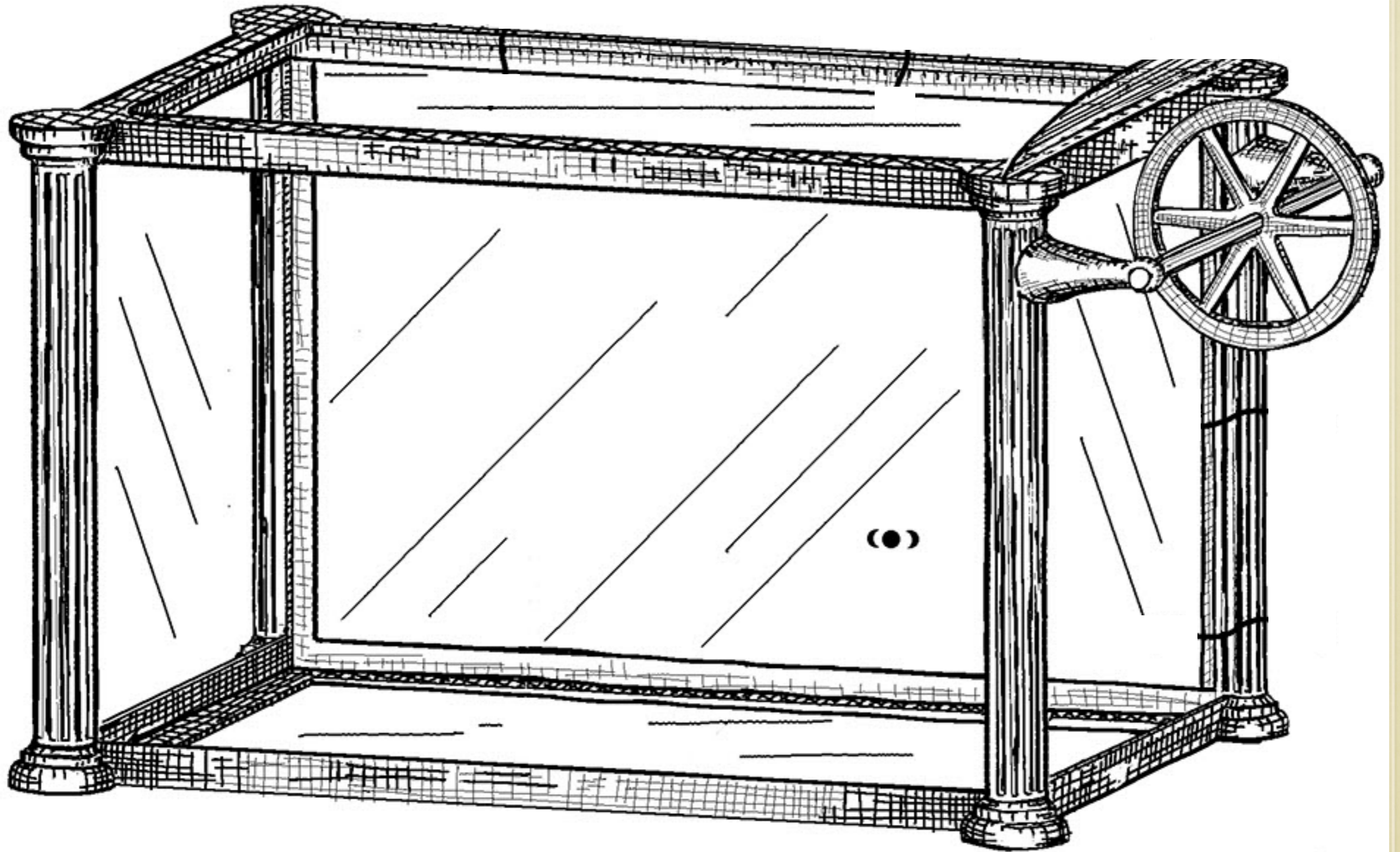






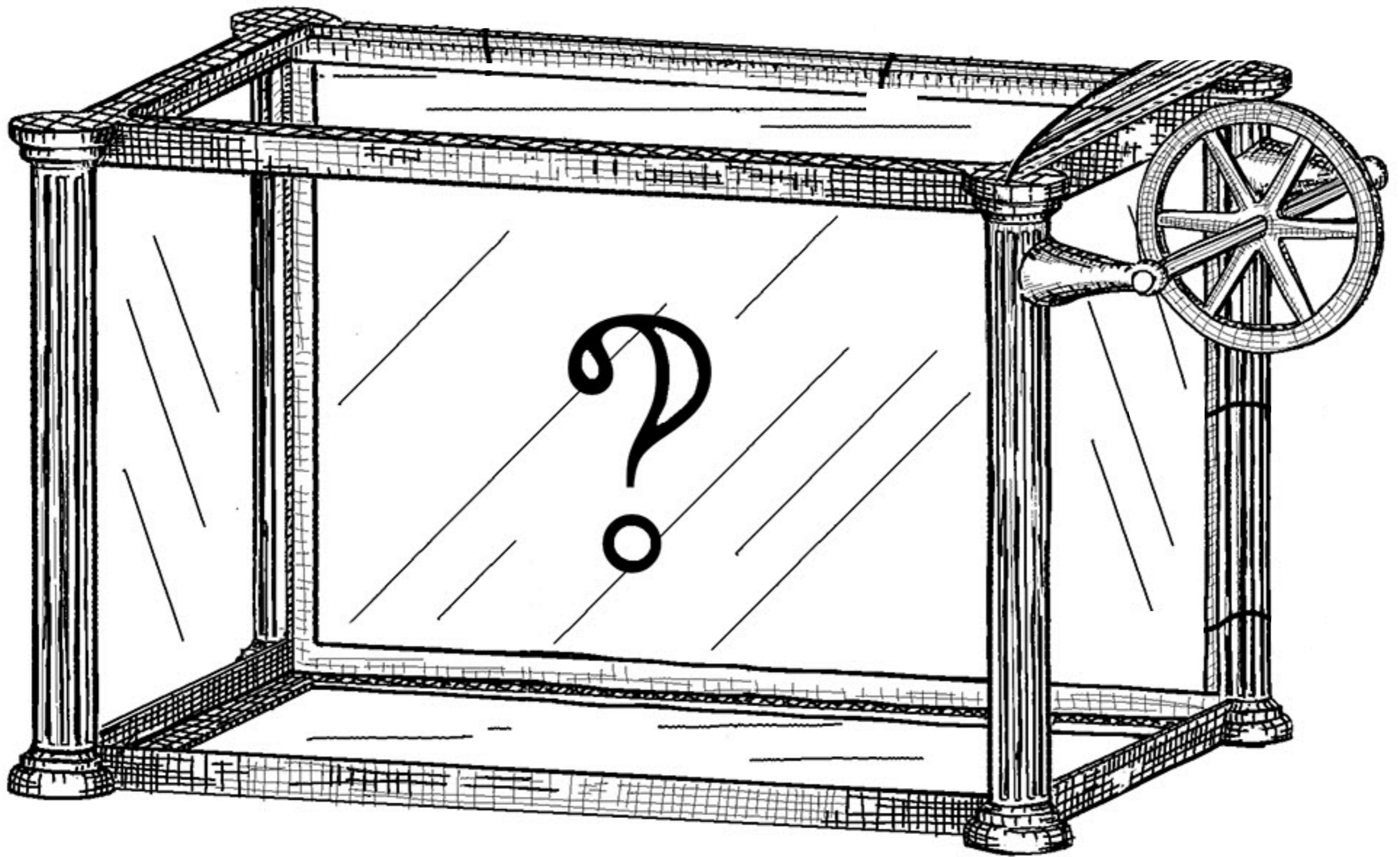




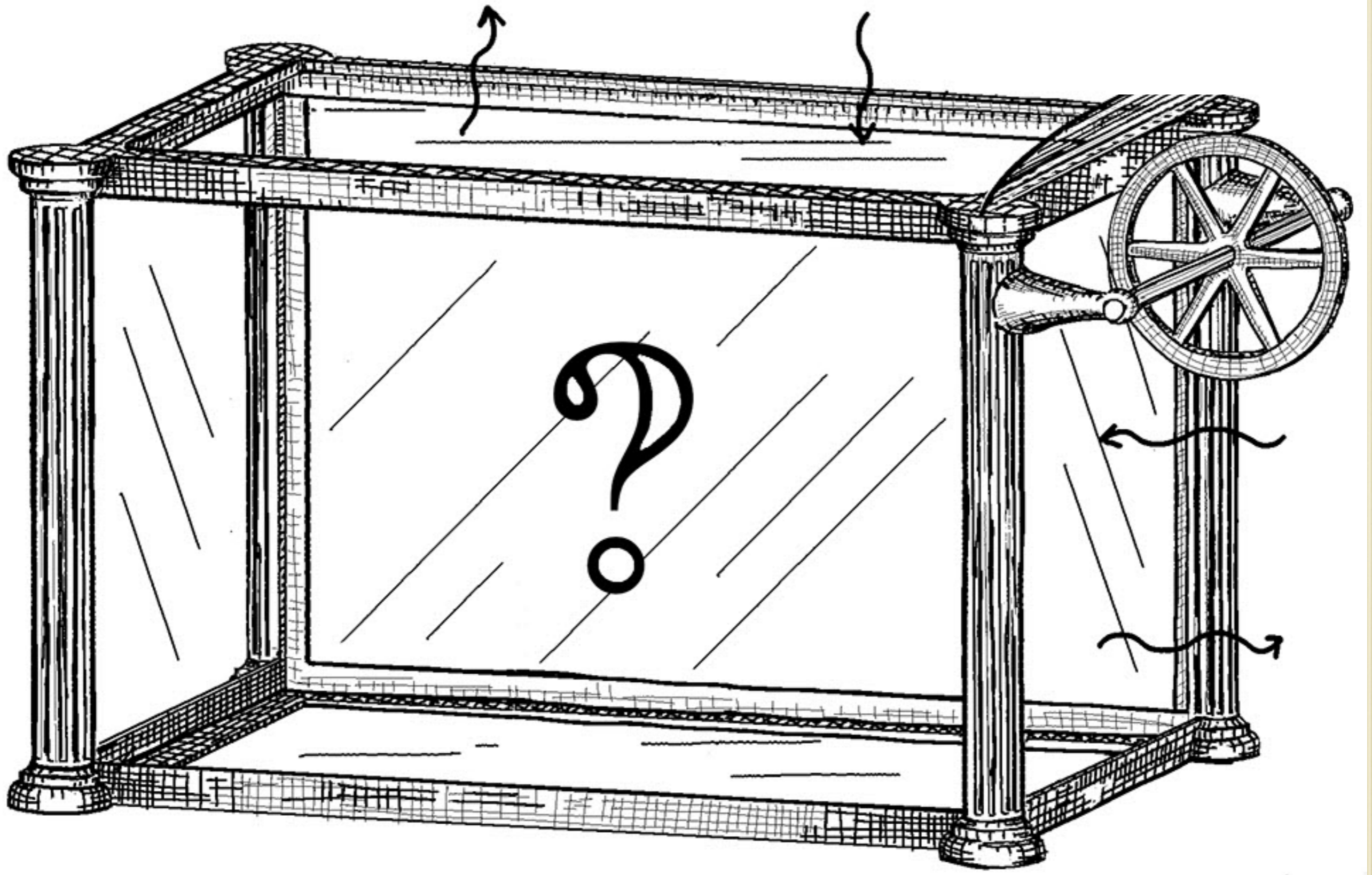


Todd Cahill

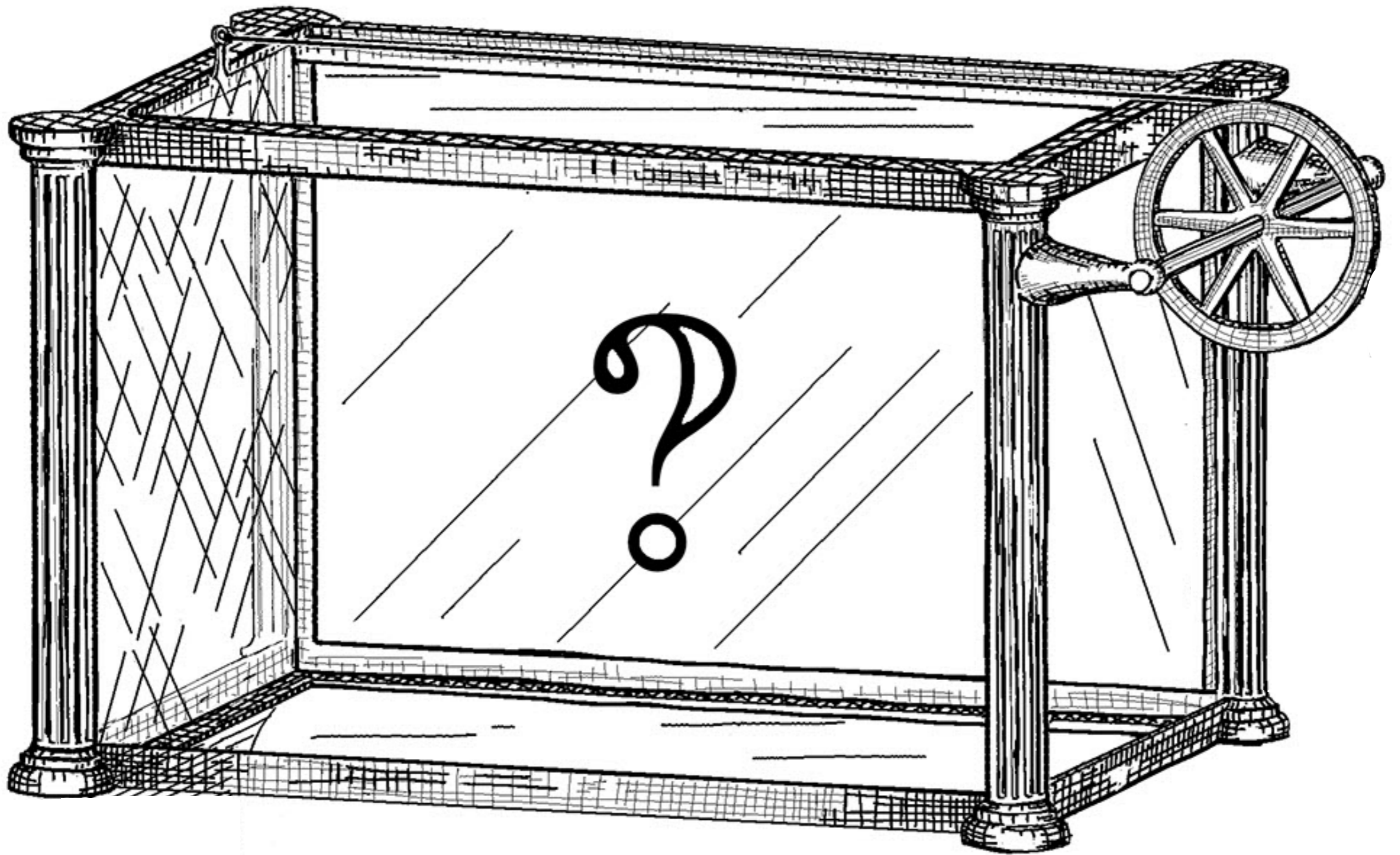




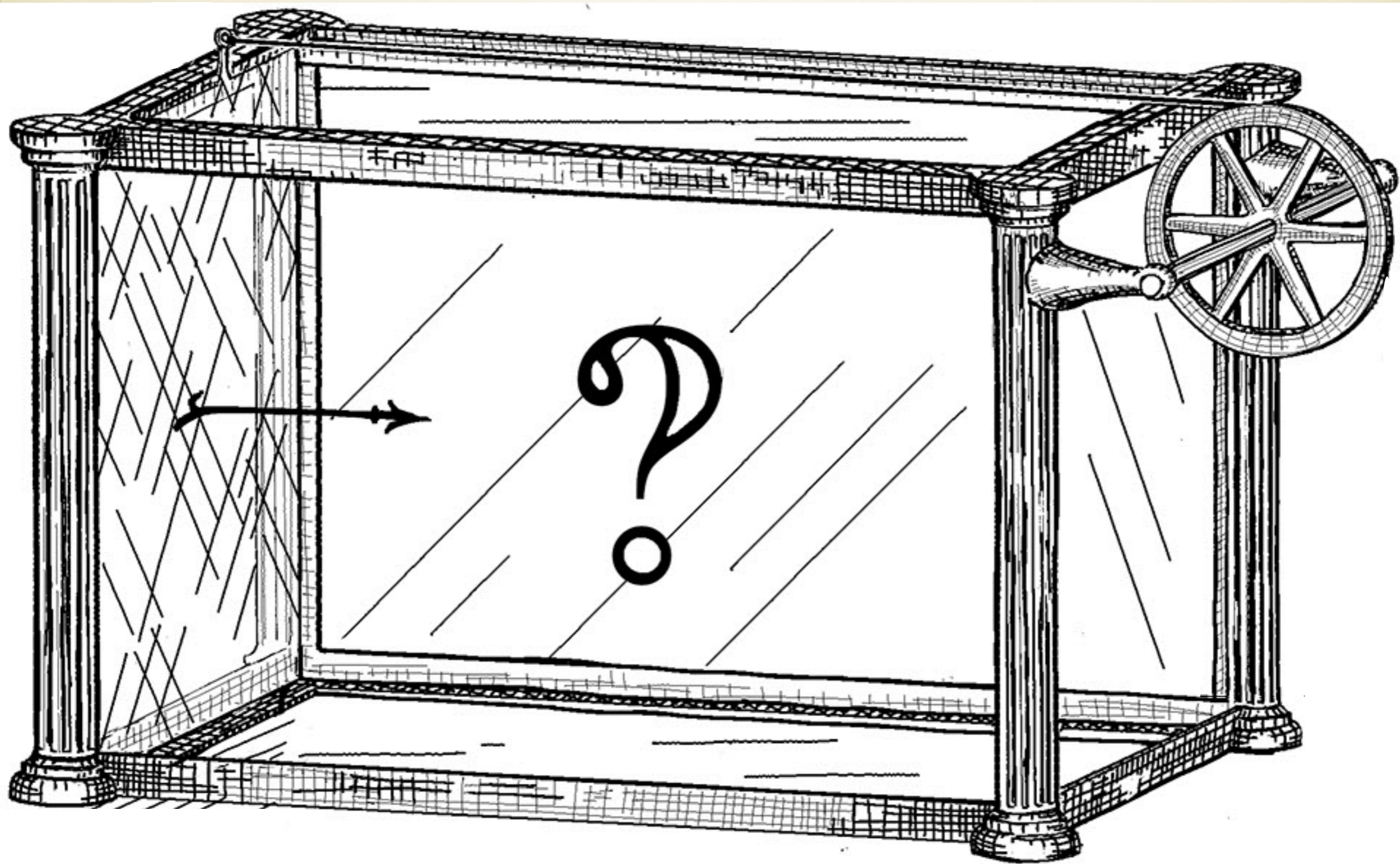




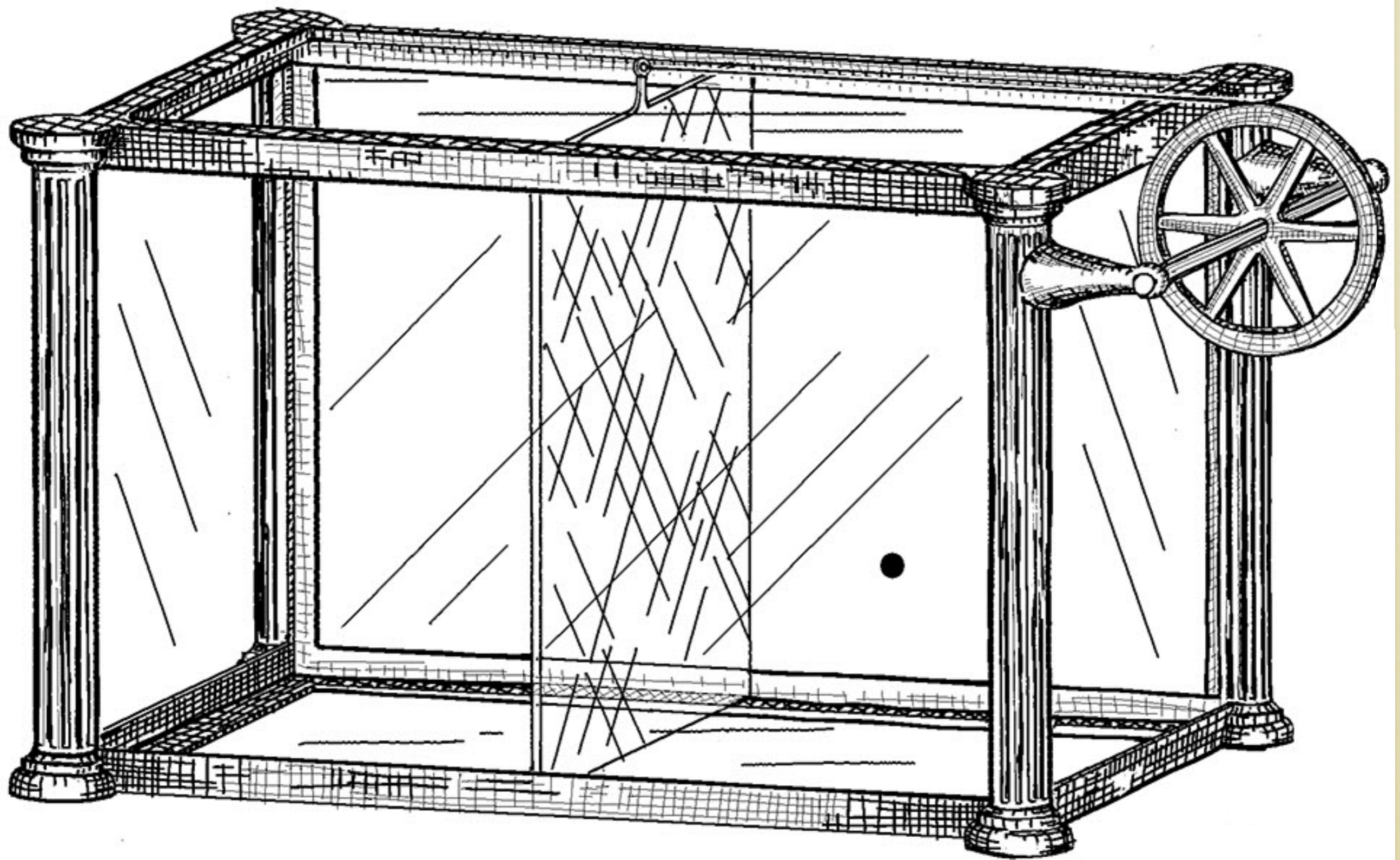












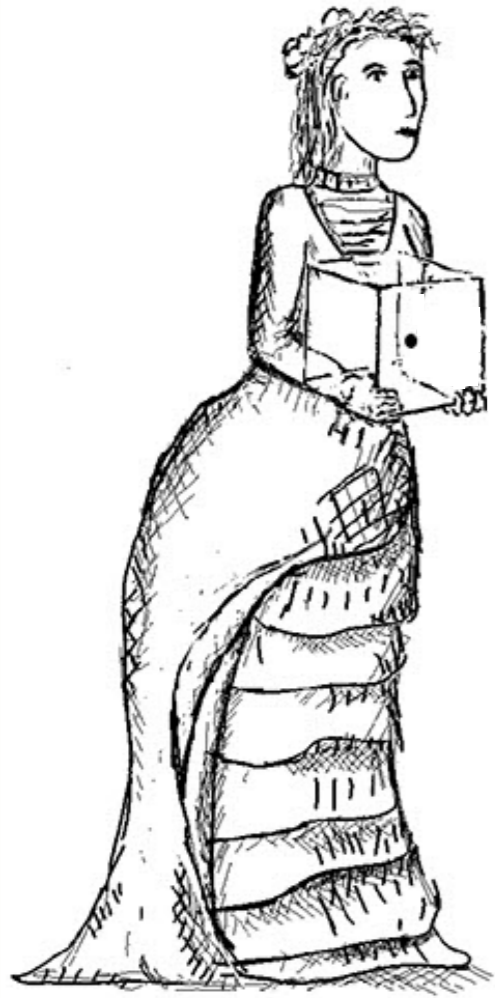


# Landauer erasure

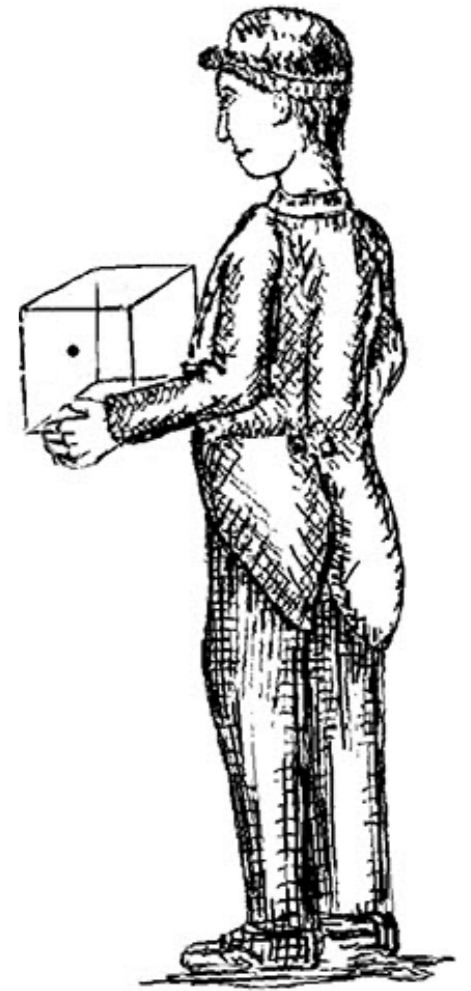


AIP Emilio Segrè Visual Archives, *Physics Today* Collection



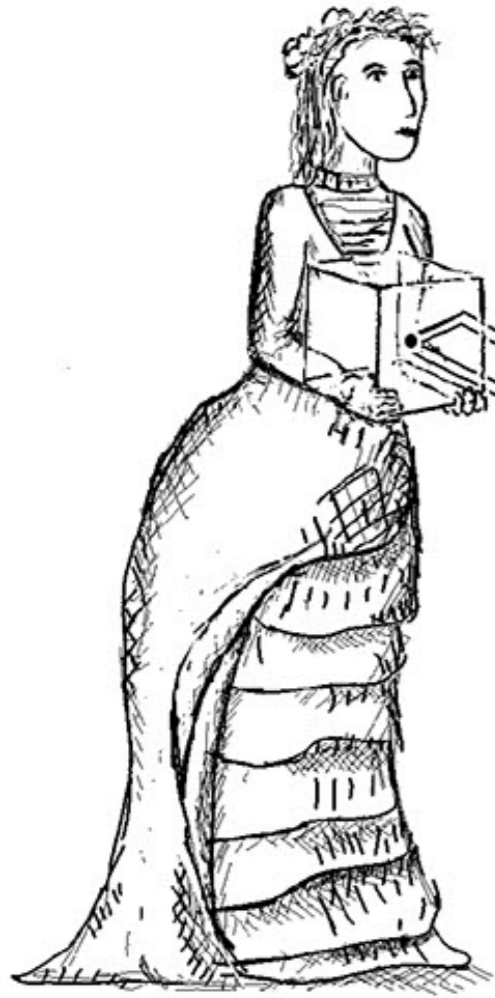


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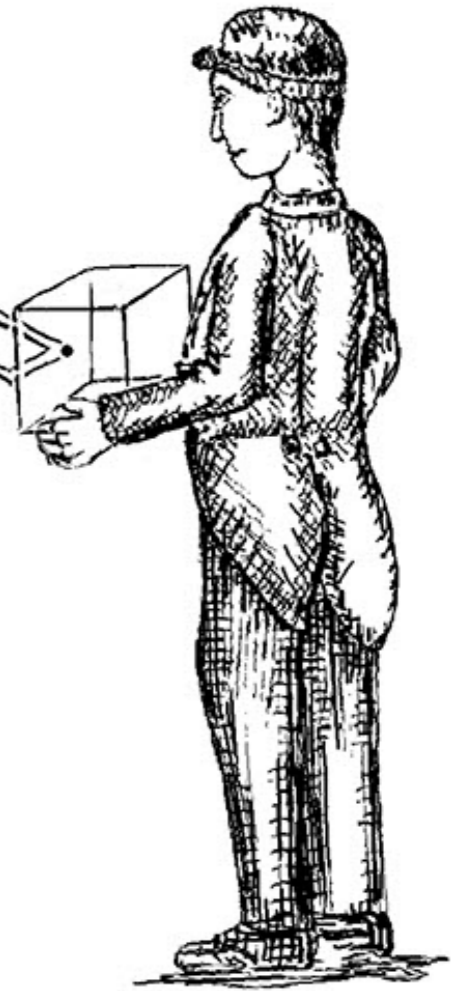


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Audrey

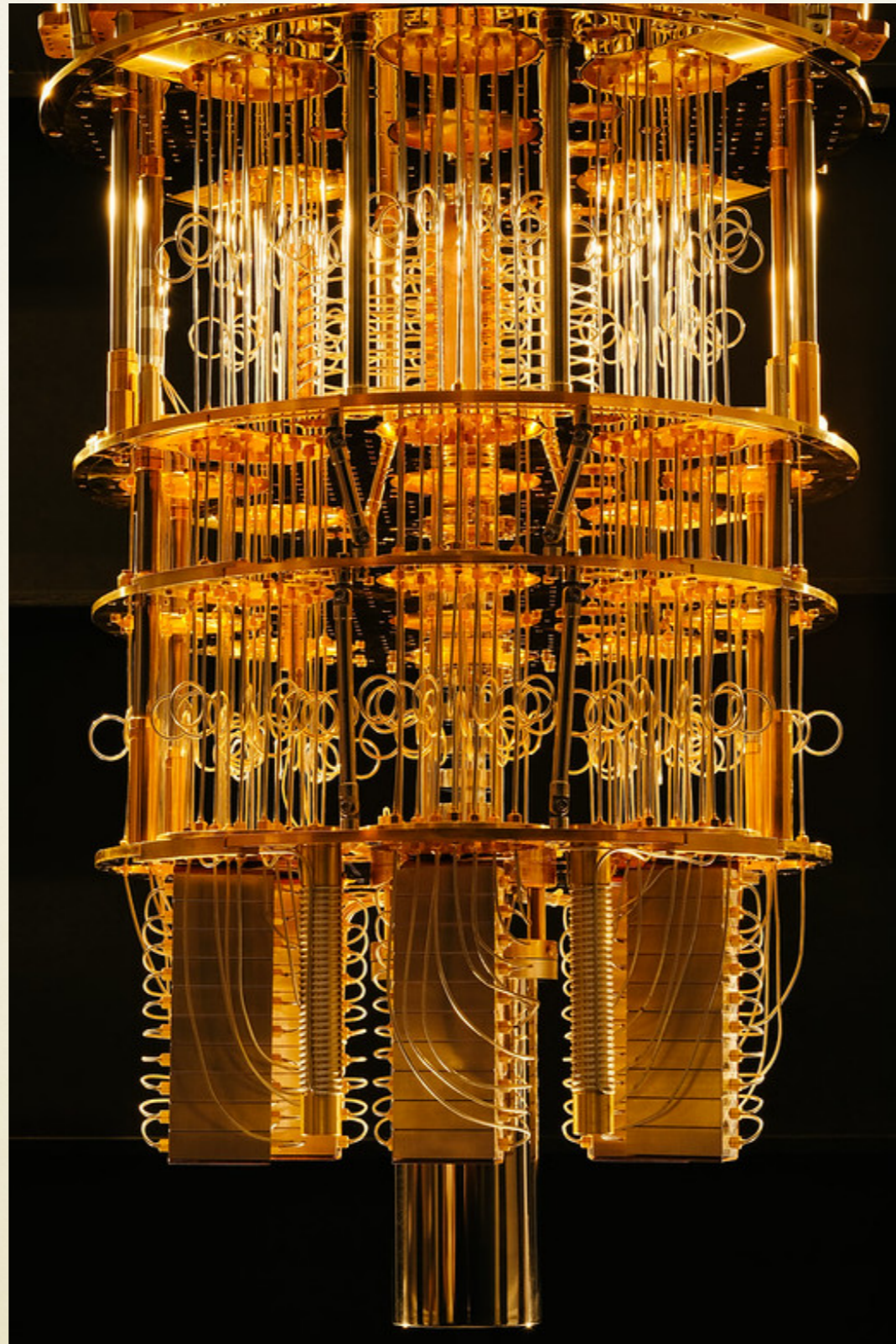


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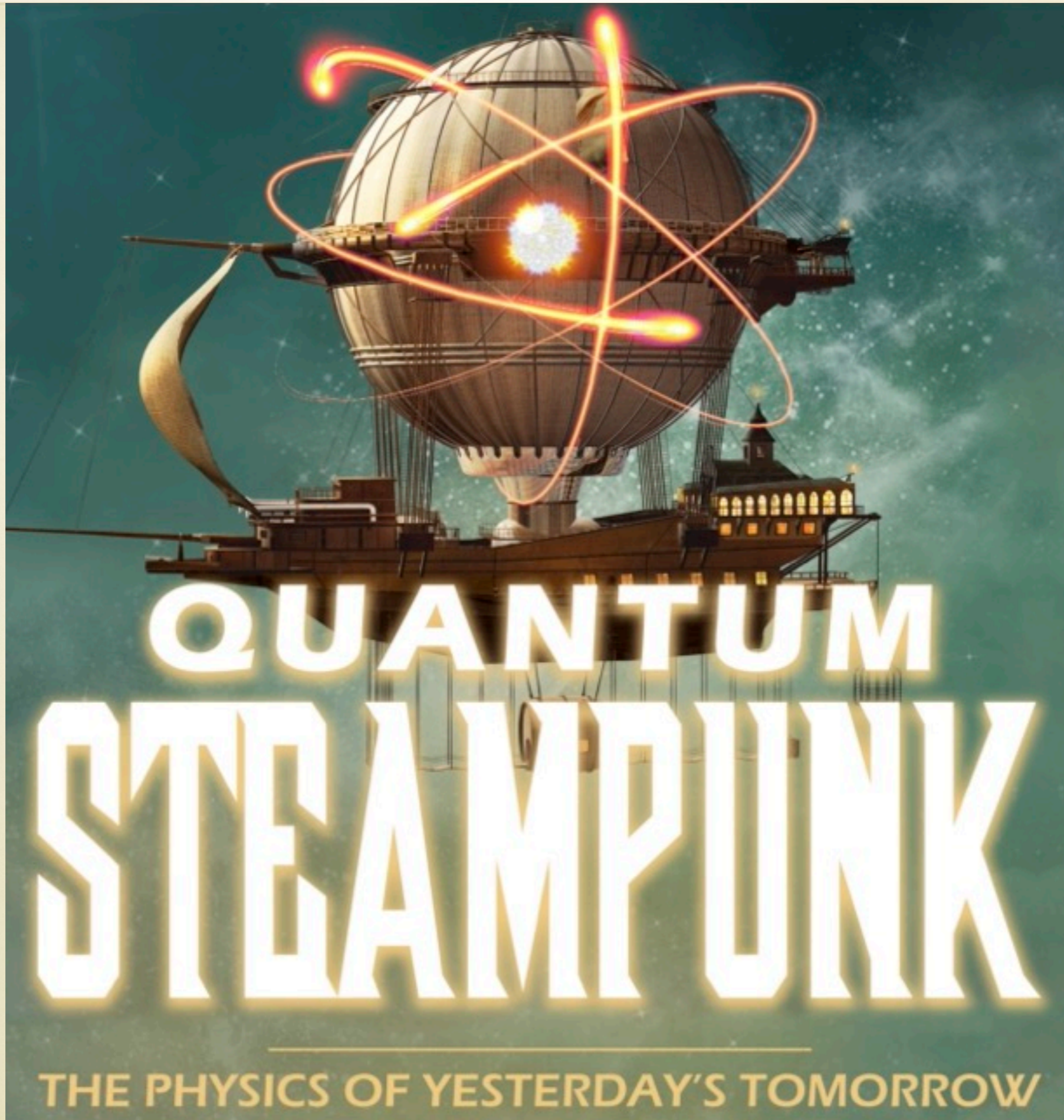












# QUANTUM STEAMPUNK

THE PHYSICS OF YESTERDAY'S TOMORROW



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