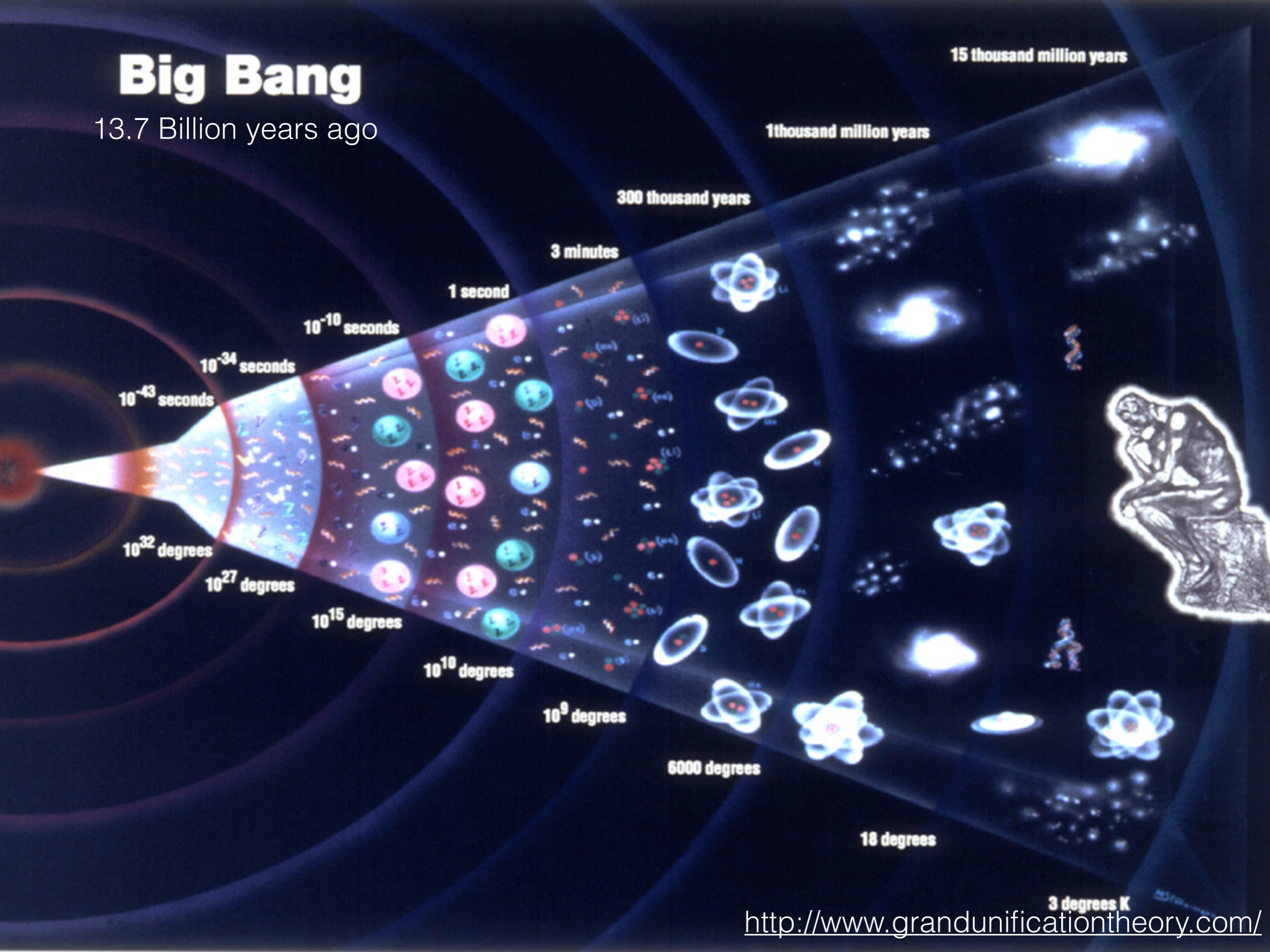


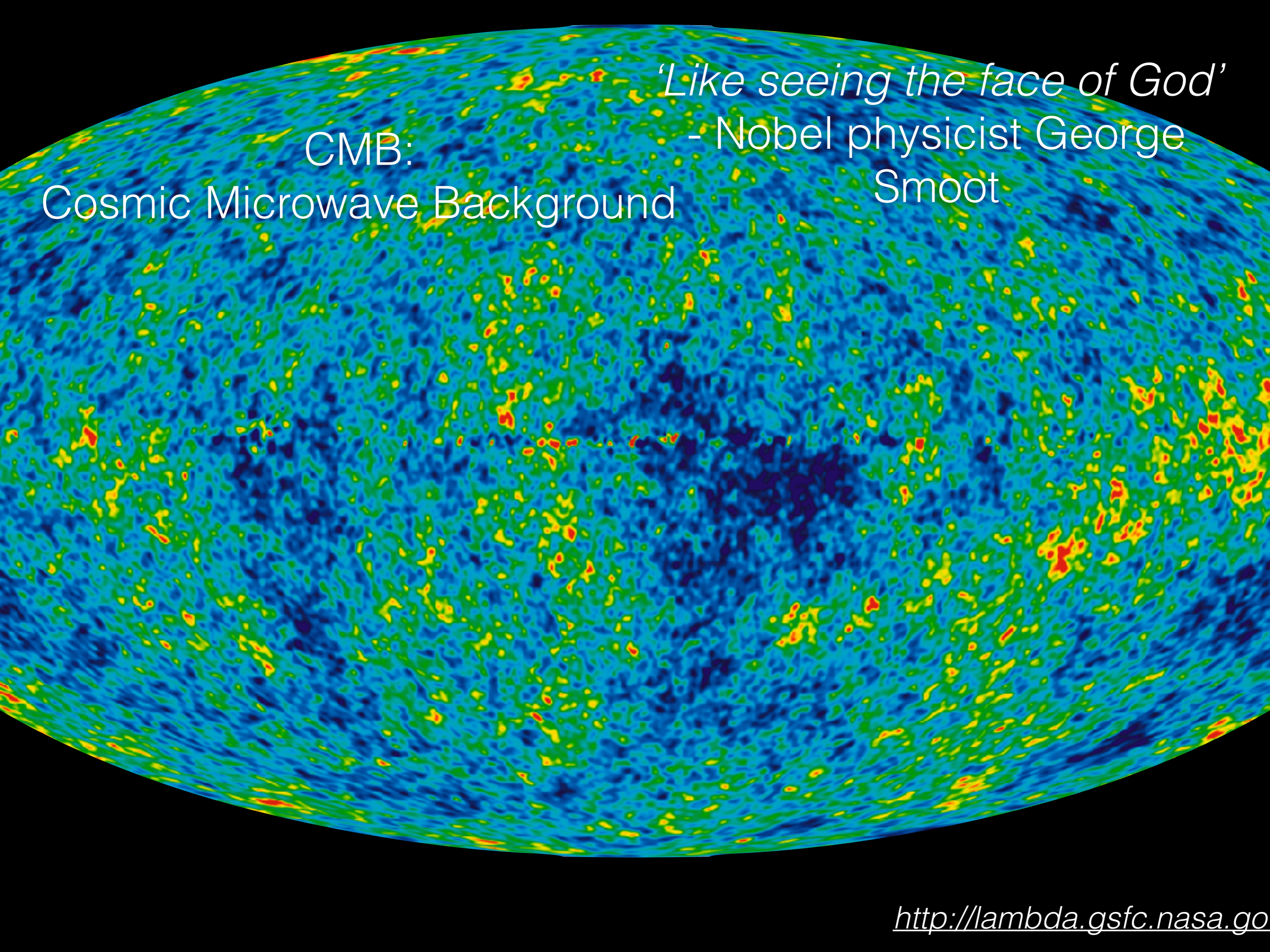


Manoj Bhargava

Big Bang

13.7 Billion years ago





CMB:
Cosmic Microwave Background

'Like seeing the face of God'
- Nobel physicist George
Smoot



4.2 billion kg of matter to energy per second

$$E=mc^2$$

so

3.7×10^{26} joules / second =

3.7×10^{26} watts

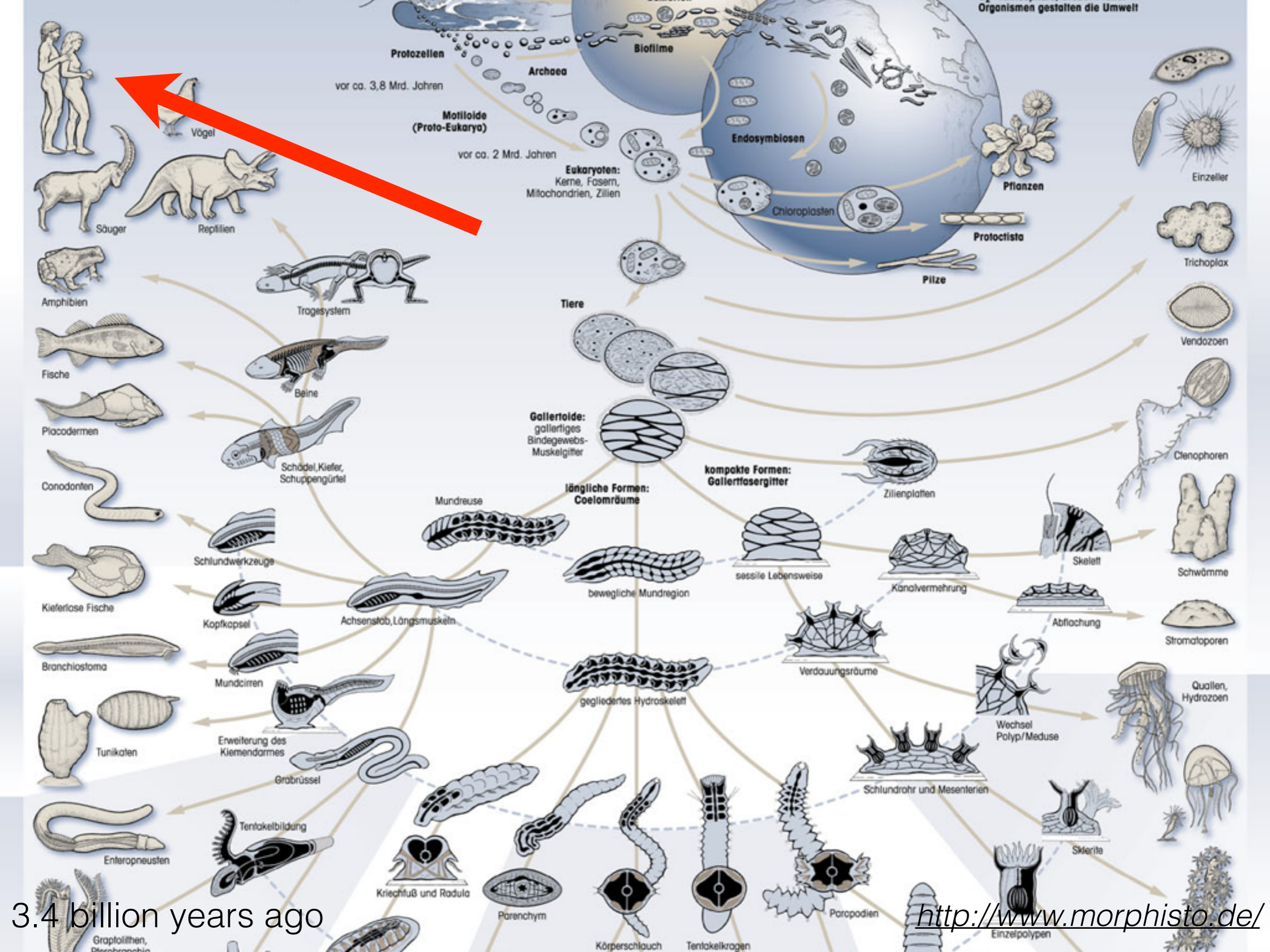
370 yottawatts!

4.6 billion years ago





3.4 billion years ago





1.7 million - 200,000 years ago



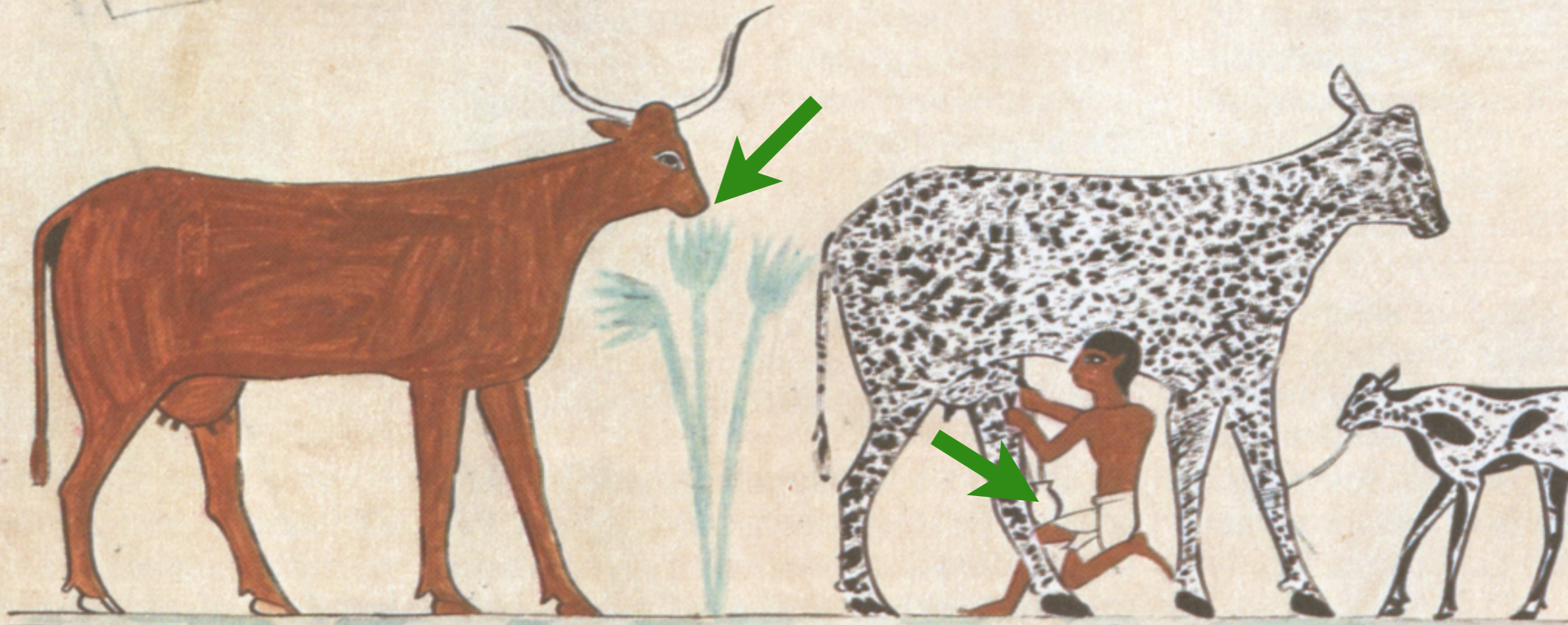


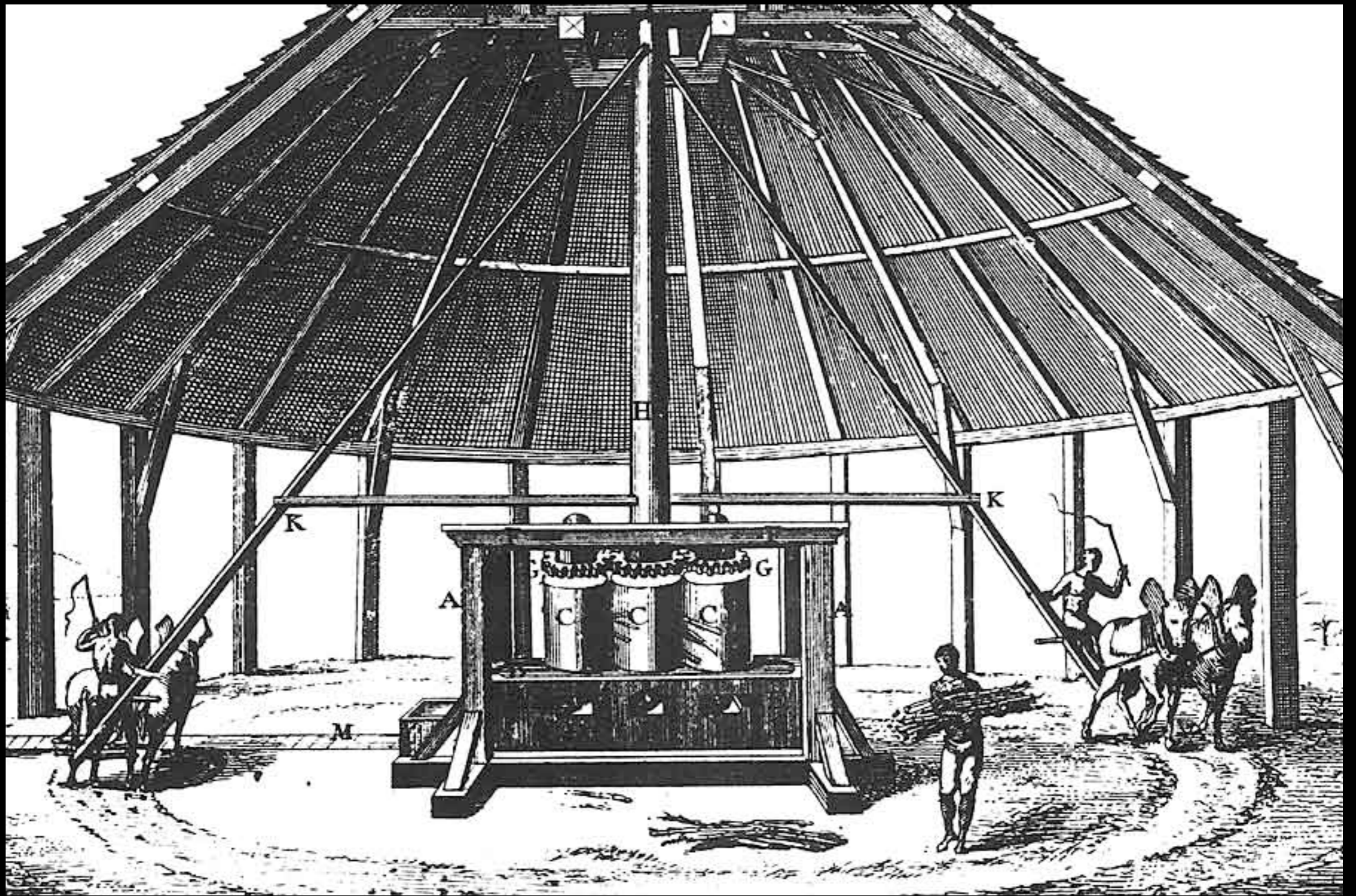


20,000-30,000 years ago



<10,000 years ago

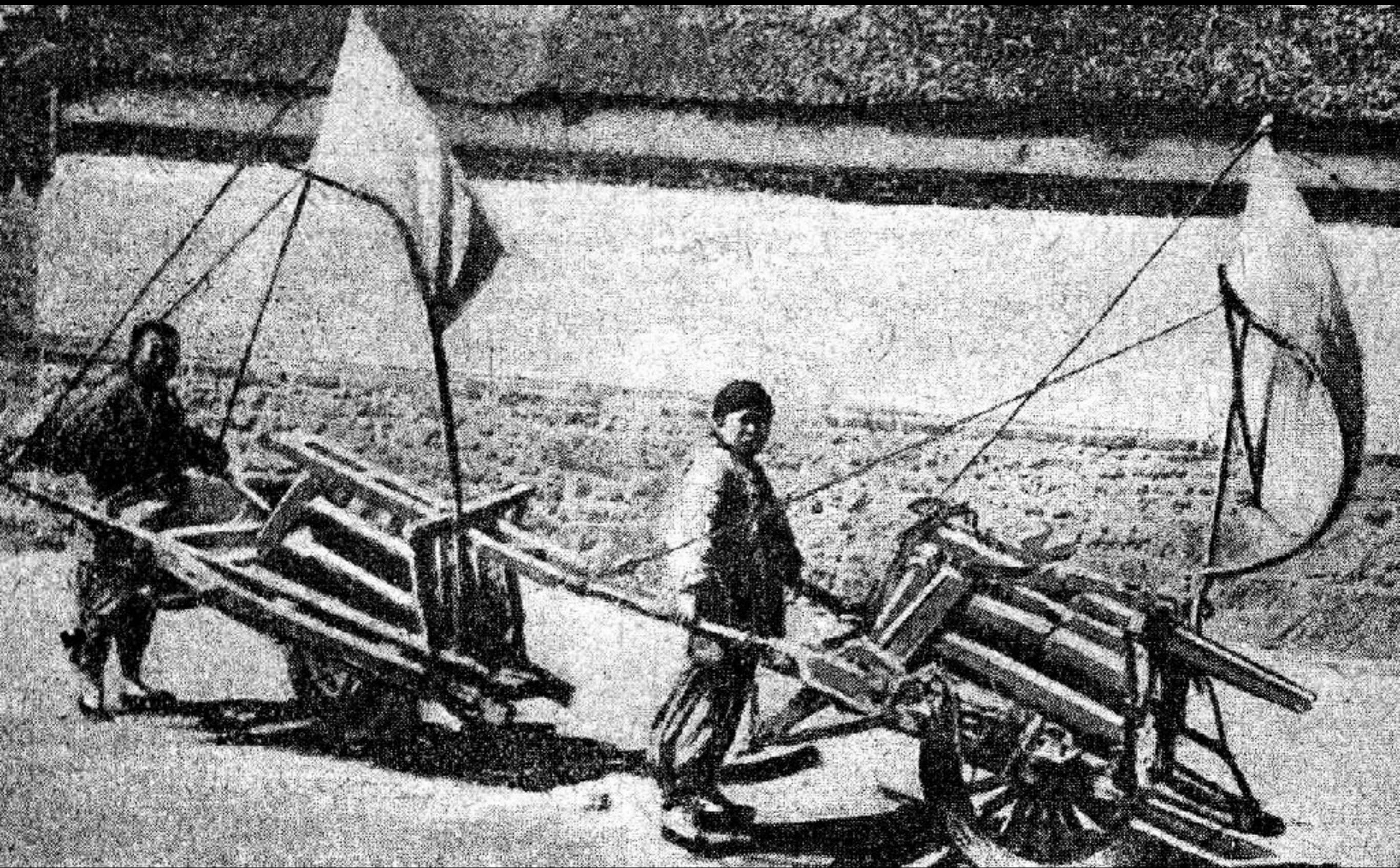








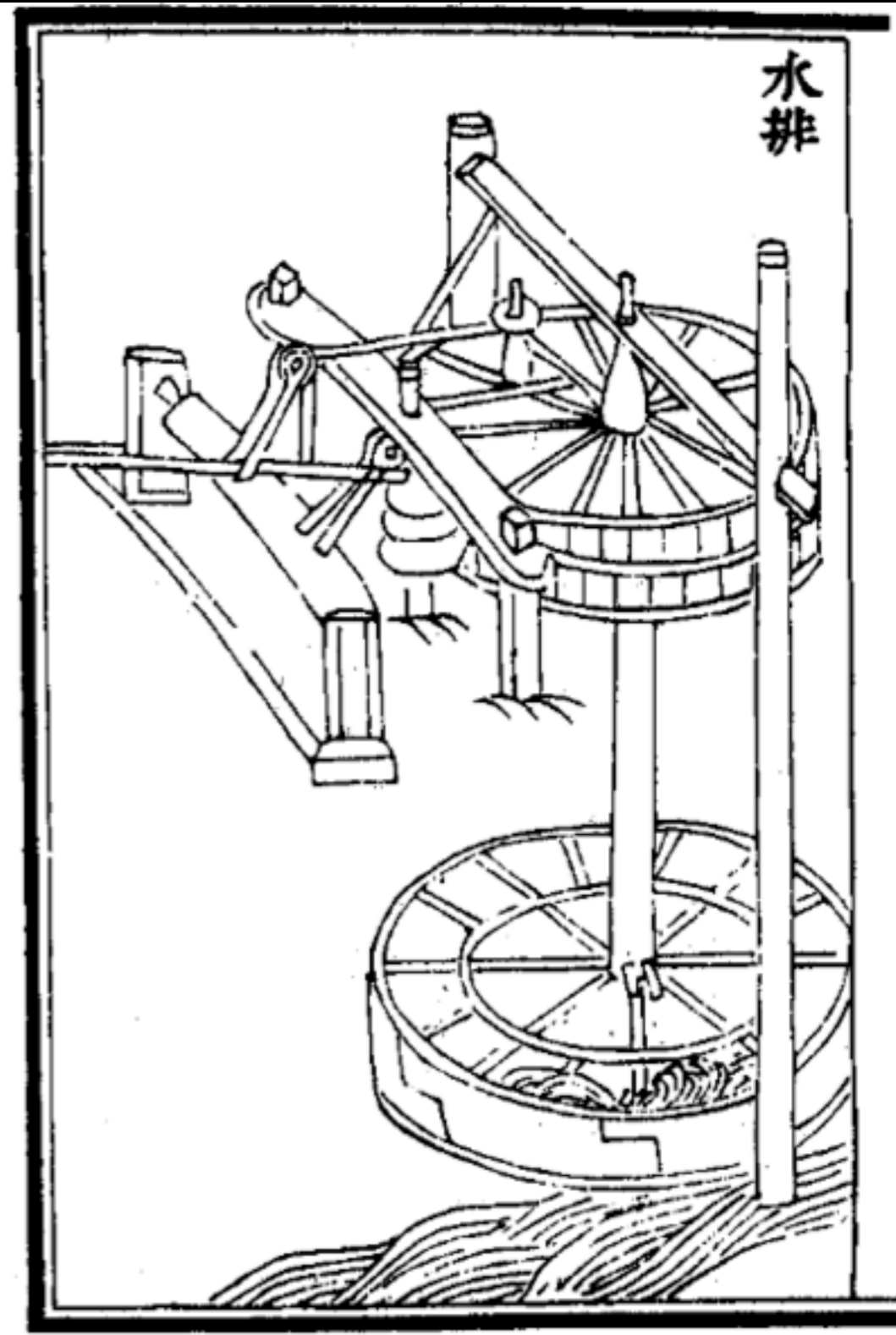




Stone Age - no fire needed

Bronze Age - 950°C

Iron Age - 1500°C

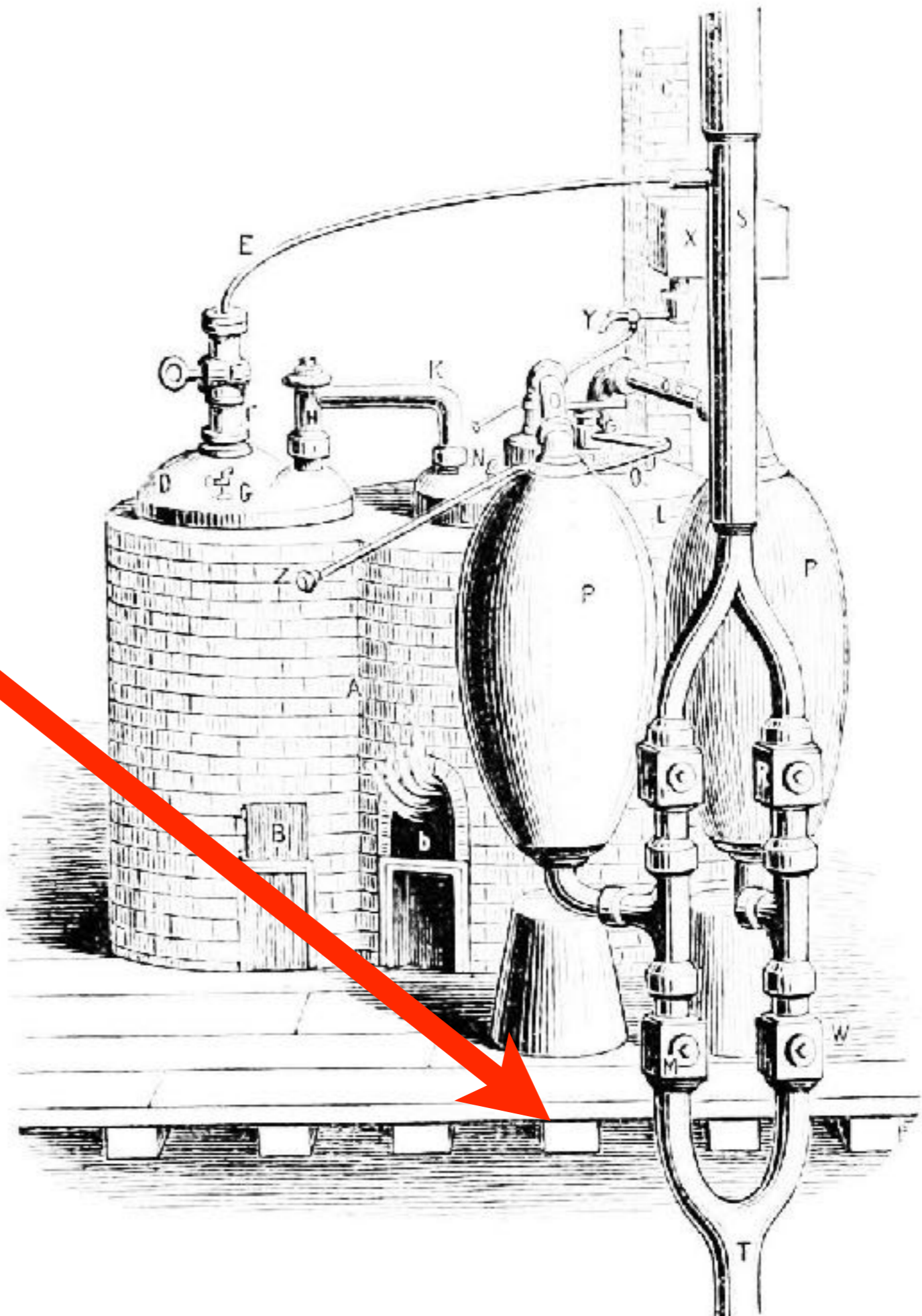




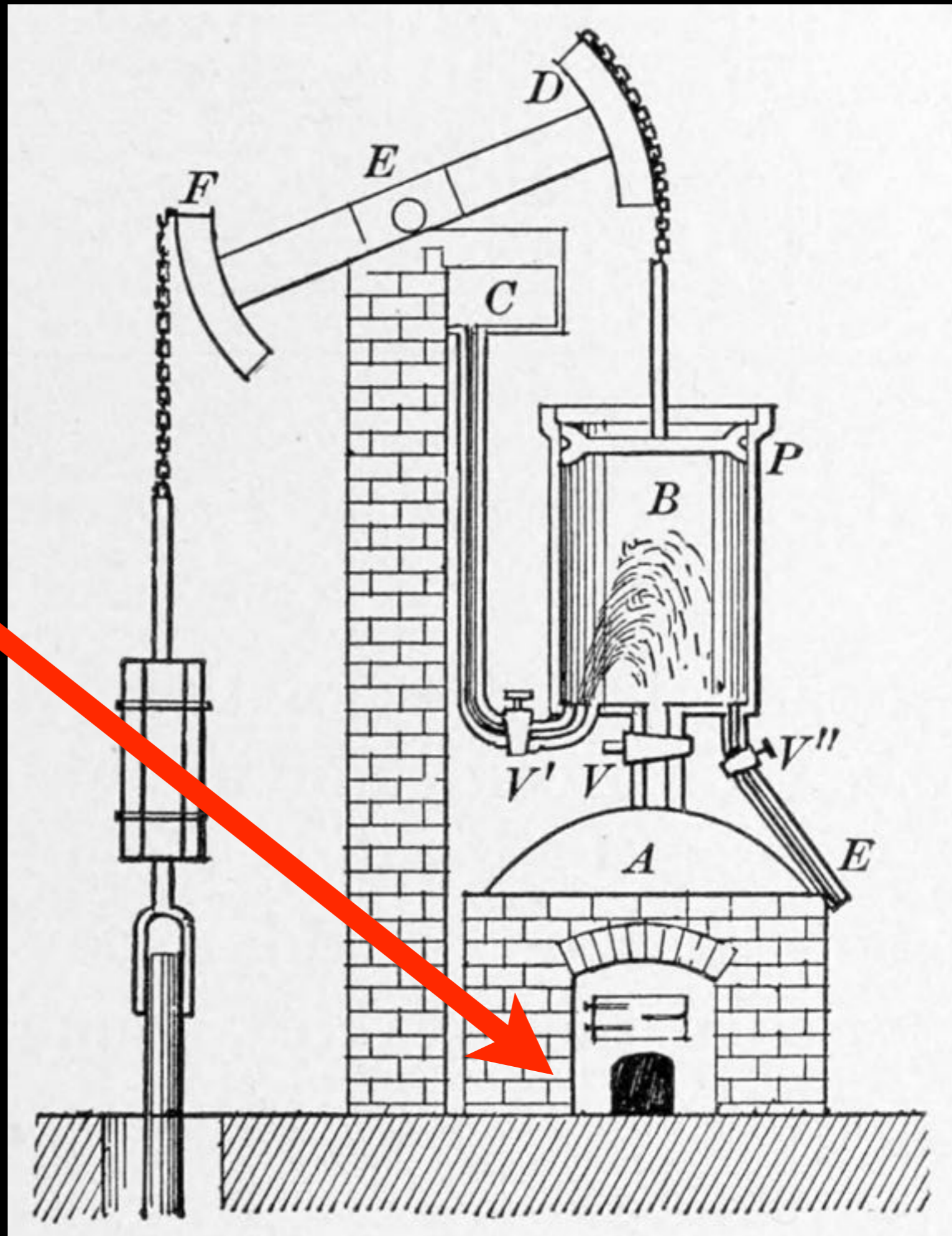
100 BC - Herona (?)



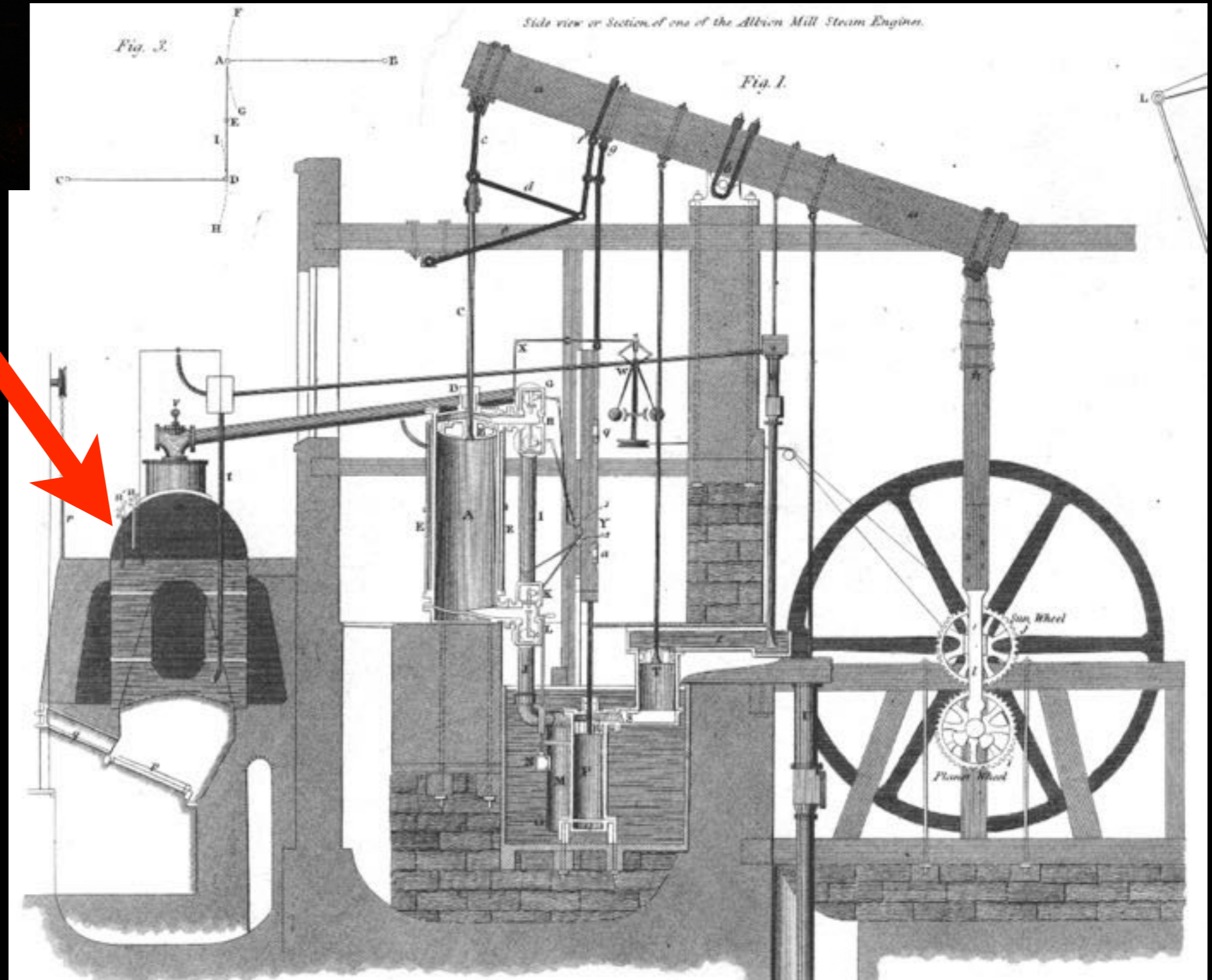
1300s - Huolongjing



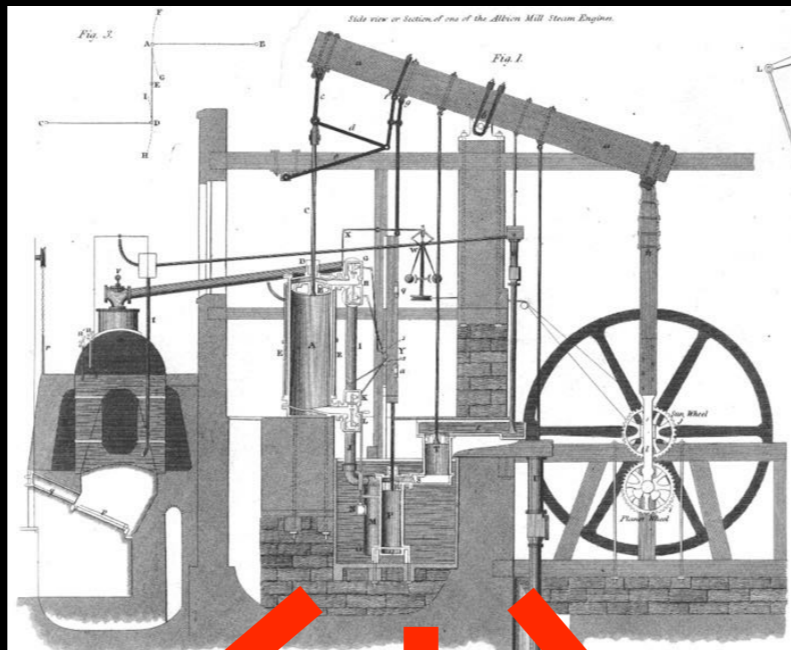
1699 - Savery



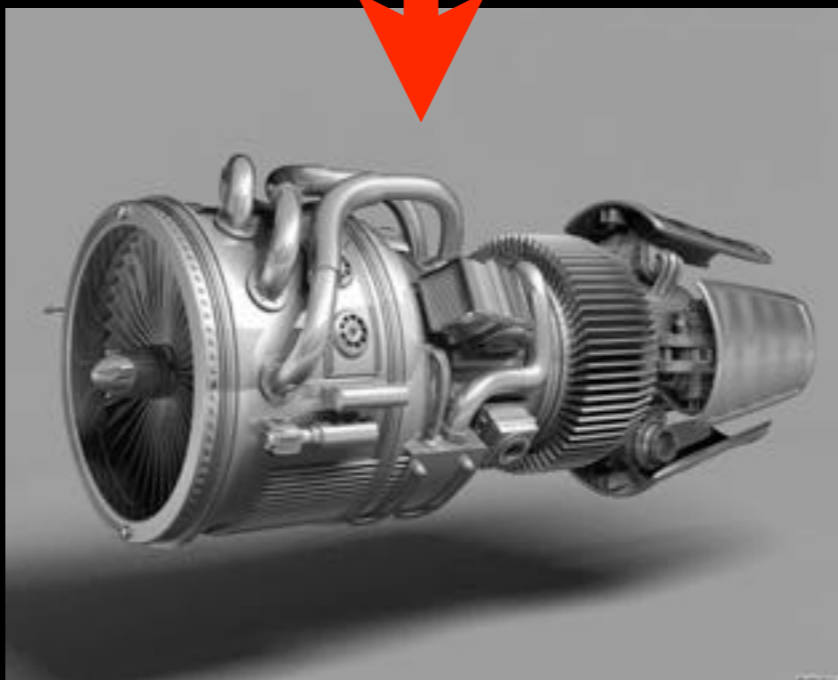
1712 - Newcomen



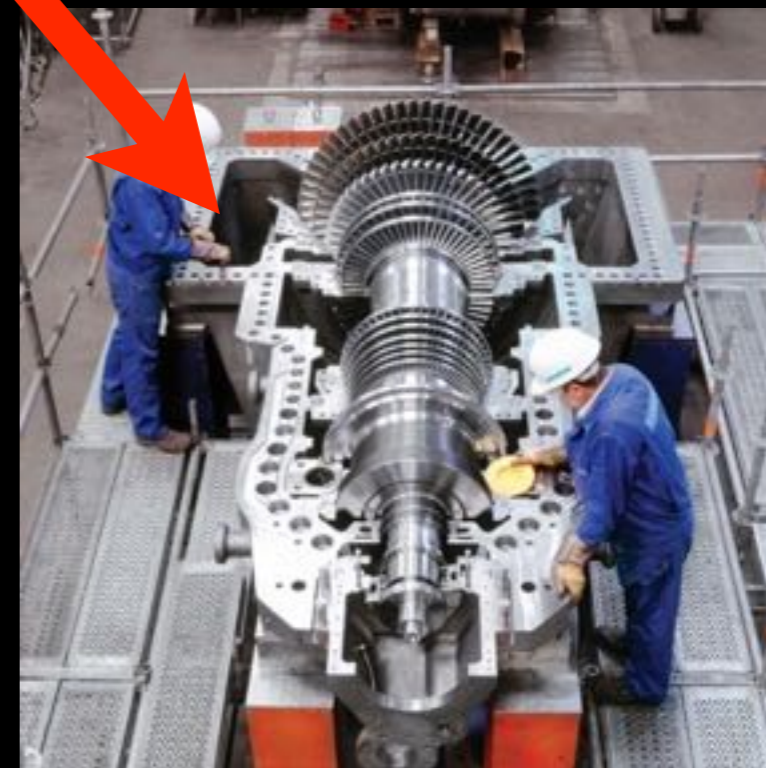
1775 - Watt



I.C.E.

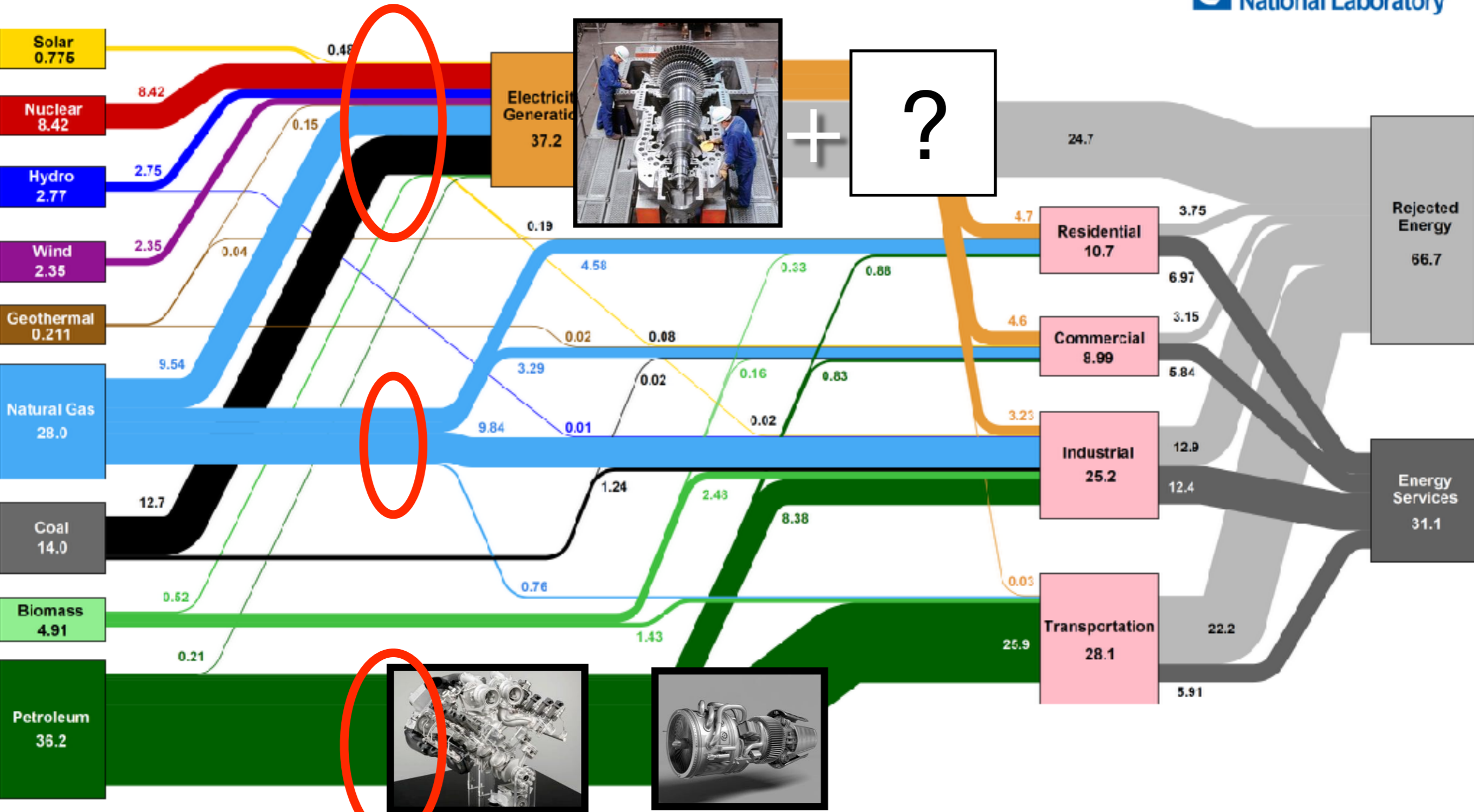


Jet engine



Steam turbine

Estimated U.S. Energy Consumption in 2017: 97.7 Quads

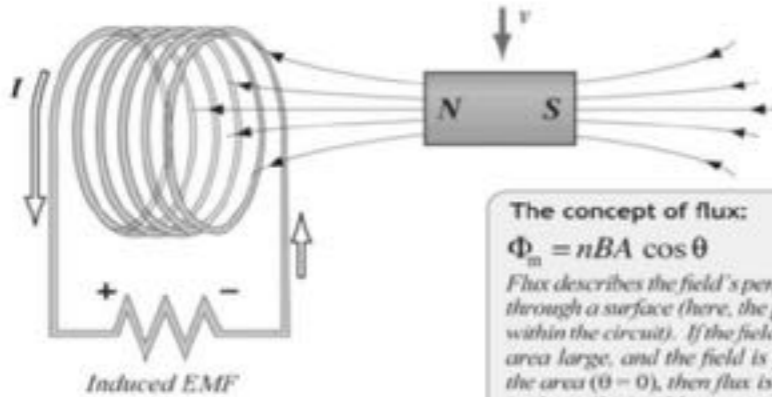


Source: EIA, April, 2018. Data based on DOE/EIA MER (2017). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. This chart was revised in 2017 to reflect changes made in mid-2015 to the Energy Information Administration's analysis methodology and reporting. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. Loss efficiency is estimated as 95% for the residential sector, 85% for the commercial sector, 21% for the transportation sector, and 49% for the industrial sector which was updated in 2017 to reflect DOE's analysis of manufacturing. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

FARADAY'S LAW

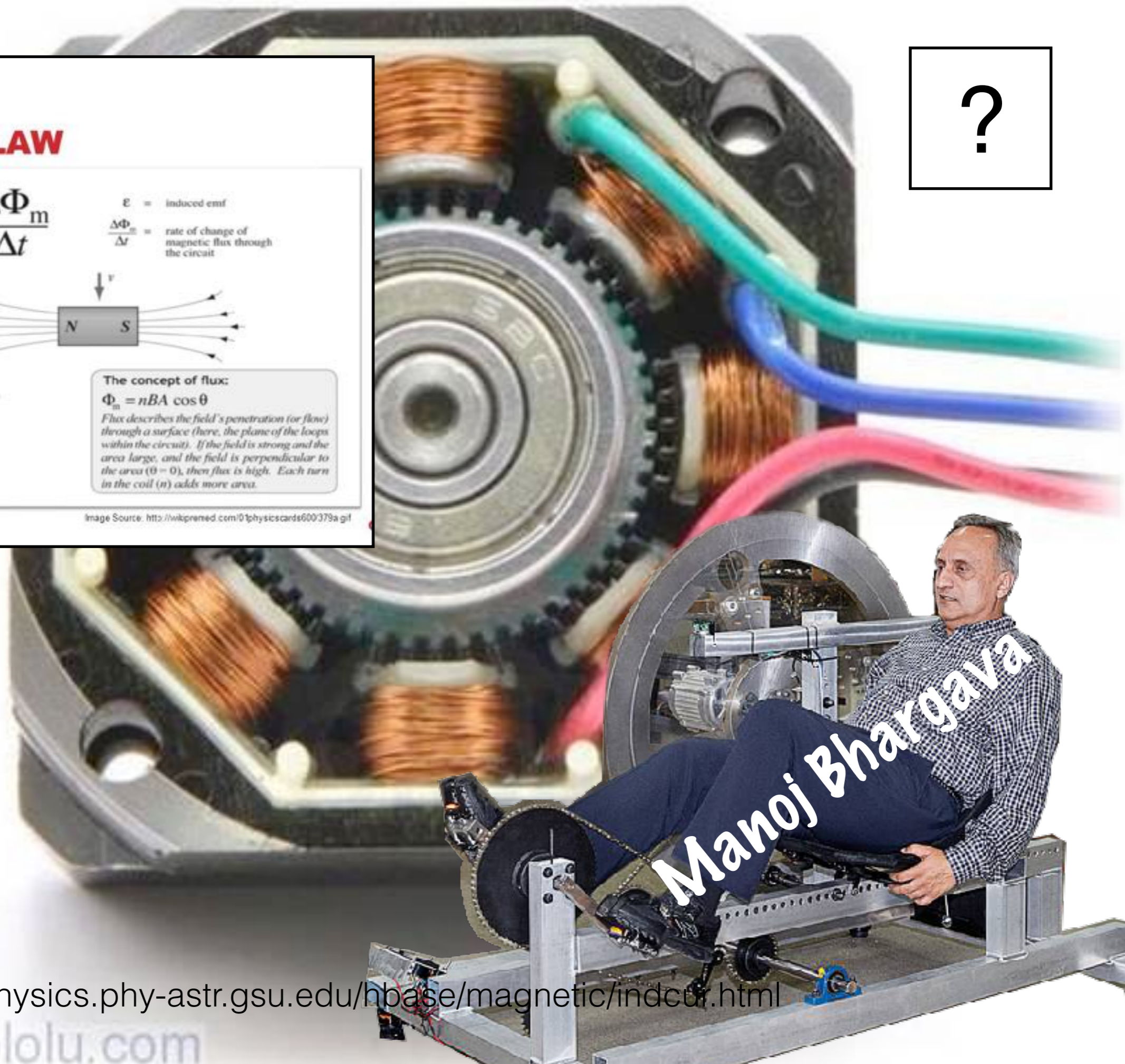
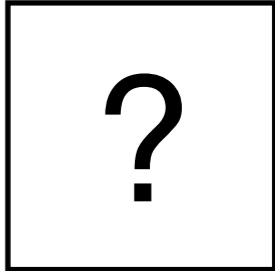
$$\varepsilon = - \frac{\Delta\Phi_m}{\Delta t}$$

ε = induced emf
 $\frac{\Delta\Phi_m}{\Delta t}$ = rate of change of magnetic flux through the circuit



The concept of flux:
 $\Phi_m = nBA \cos \theta$
Flux describes the field's penetration (or flow) through a surface (here, the plane of the loops within the circuit). If the field is strong and the area large, and the field is perpendicular to the area ($\theta = 0$), then flux is high. Each turn in the coil (n) adds more area.

Image Source: <http://wikipreied.com/01physicscards600379a.gif>



Manoj Bhargava