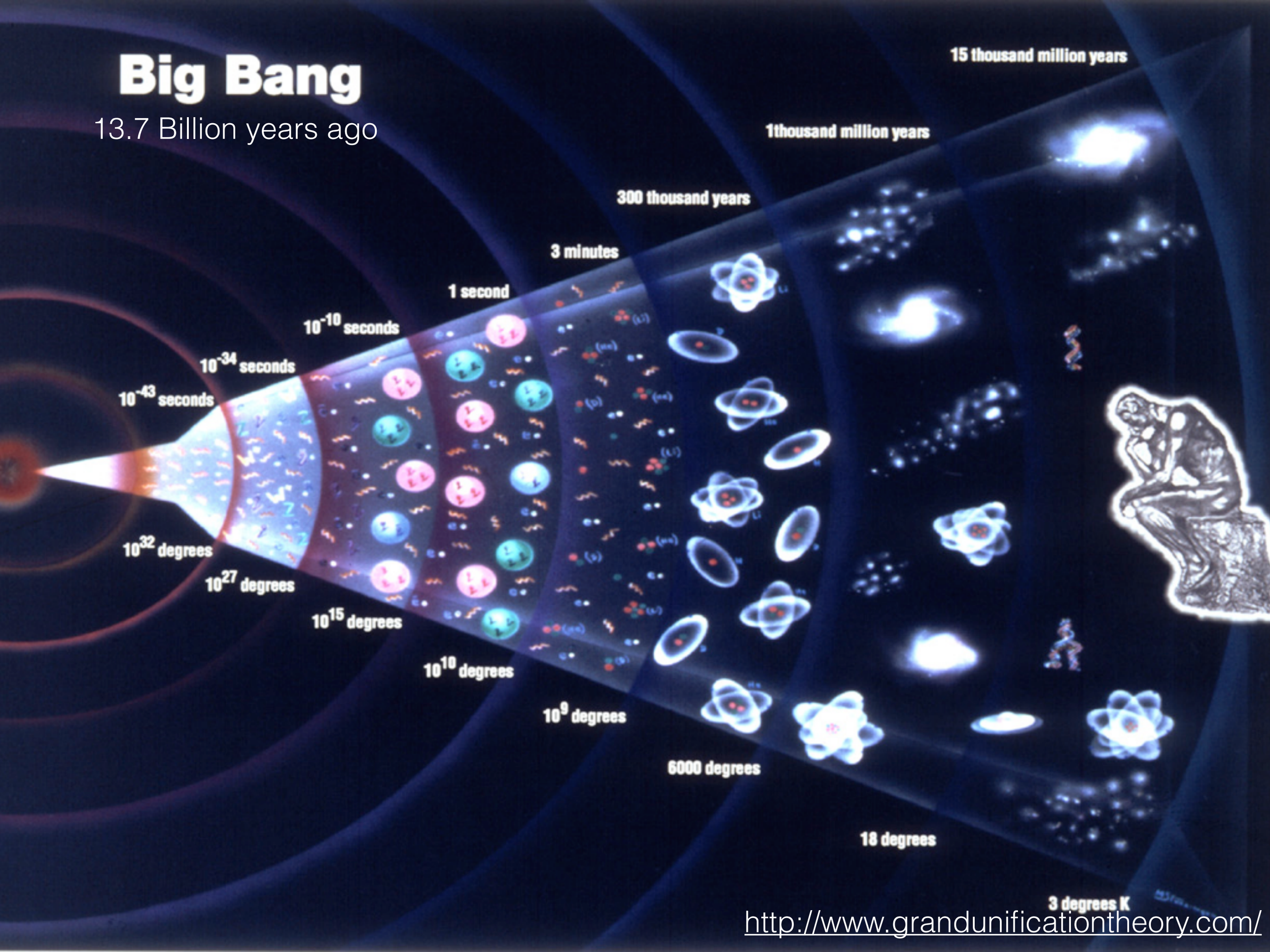
Manoj Bhargava

ITP/NYU/Feddersen

Big Bang

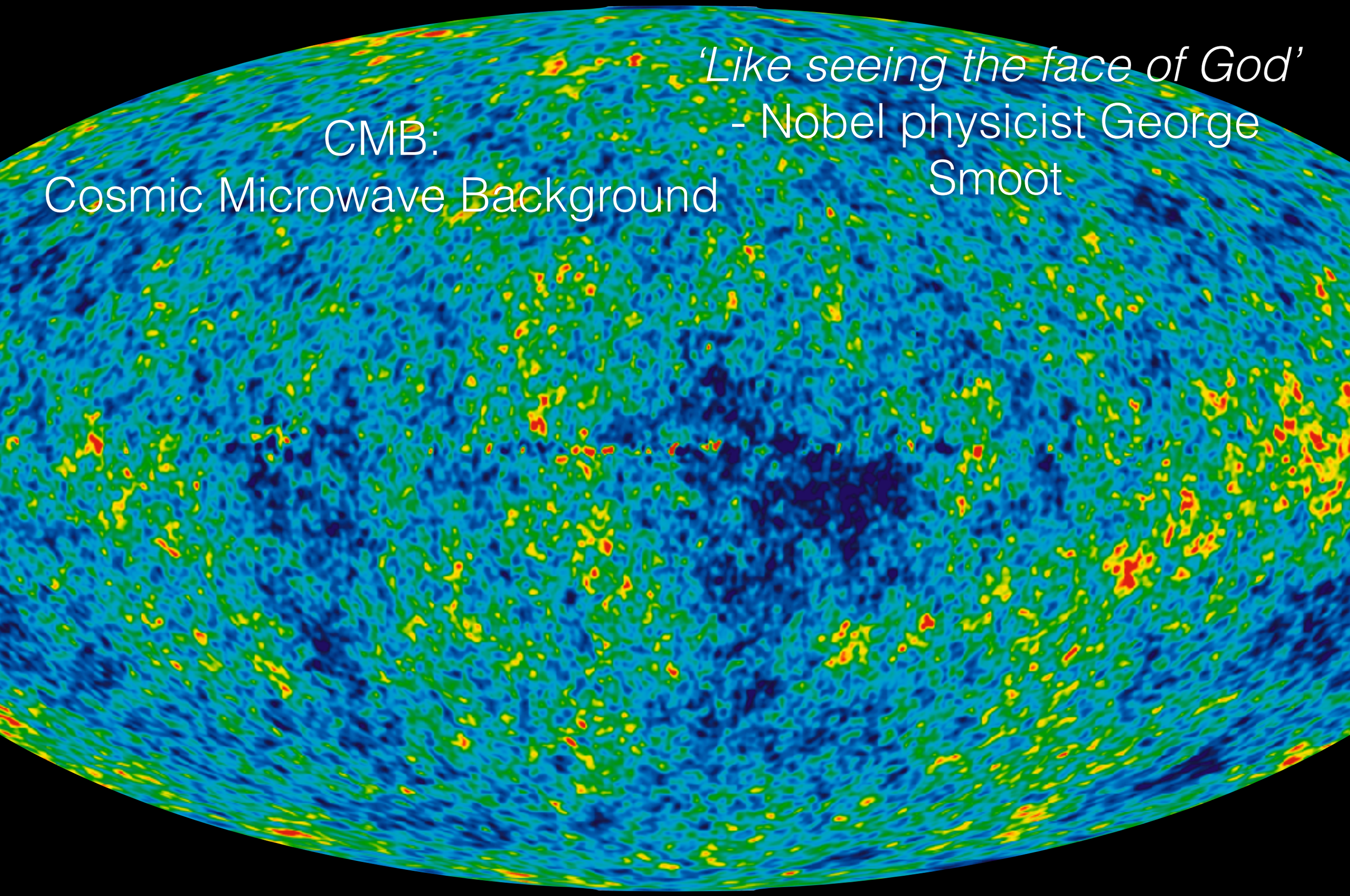
13.7 Billion years ago



http://www.grandunificationtheory.com/

CMB:
Cosmic Microwave Background

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



http://lambda.gsfc.nasa.go

http://www.universetoday.com

4.2 billion kg of matter to energy per second

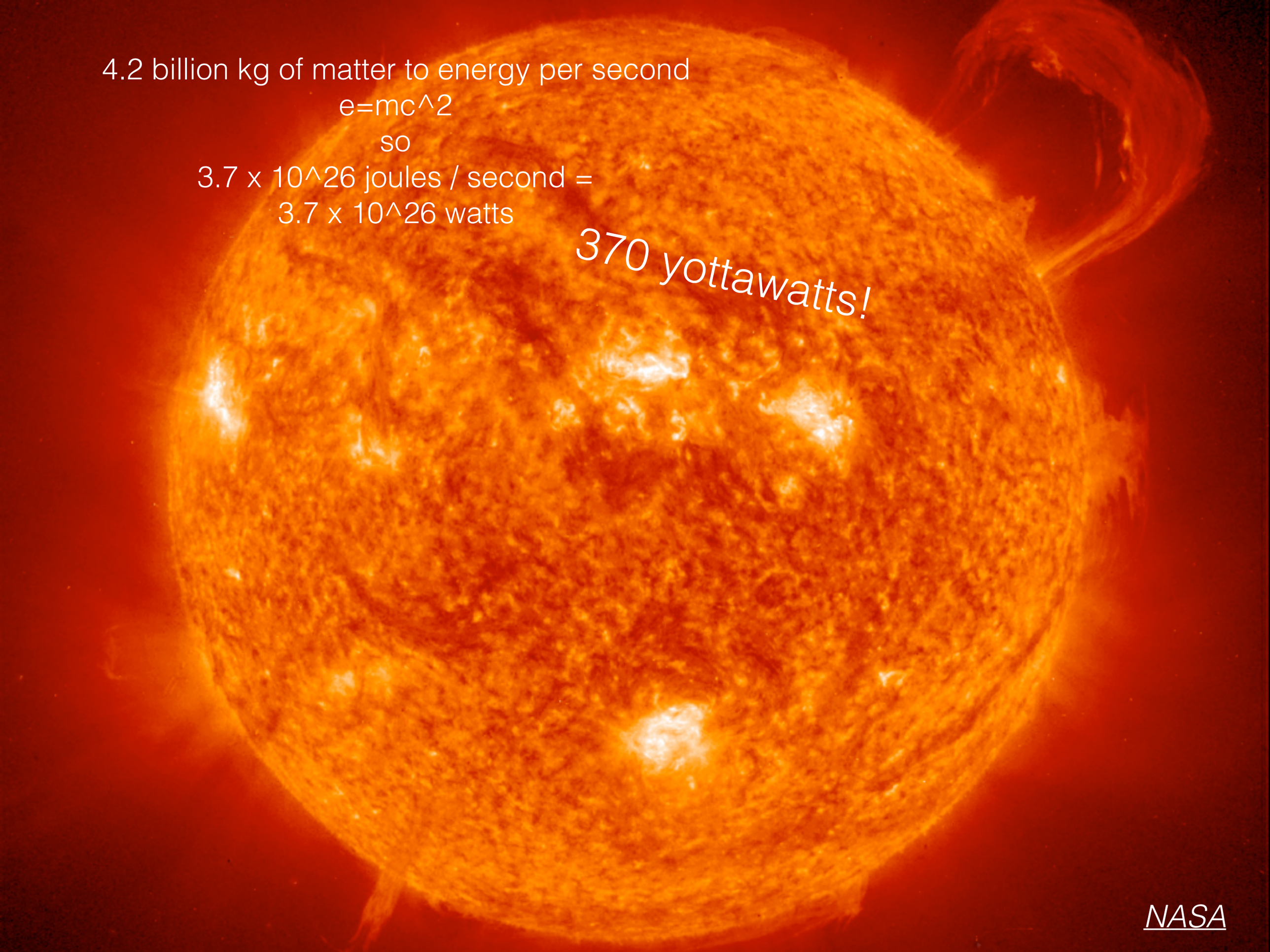
e=mc^2

so

3.7 x 10^26 joules / second =

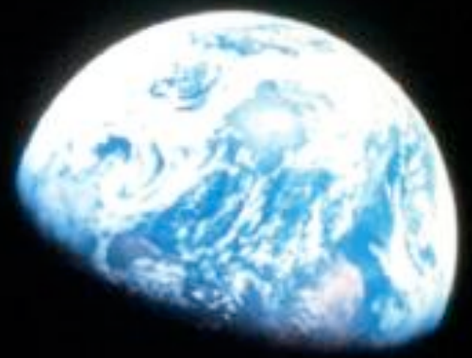
3.7 x 10^26 watts

370 yottawatts!



NASA

4.6 billion years ago



NASA

3.4 billion years ago

http://
arch.ced.berkeley.edu

Organismen gestalten die Umwelt

Protozellen

Archaea

Biofilme

vor ca. 3,8 Mrd. Jahren

Motiloide
(Proto-Eukarya)

vor ca. 2 Mrd. Jahren

Eukaryoten:
Kerne, Fasern,
Mitochondrien, Zillen

Endosymbiosen

Chloroplasten

Pflanzen

Protoctista

Pilze

Tiere

Vögel

Säuger

Reptilien

Amphibien

Trogesystem

Fische

Beine

Placodermen

Schädel, Kiefer,
Schuppengürtel

Conodonten

Schlundwerkzeuge

Kieferlose Fische

Kopfkapsel

Achsenstab, Längsmuskeln

Branchiostoma

Mundcirren

Tunikaten

Erweiterung des
Kiemendarmes

Grabrüssel

Enteropneusten

Tentakelbildung

Graptolithen,

Kriechfuß und Radula

Parenchym

Körperschlauch

Tentakelkragen

Gallertoide:
gallertiges
Bindegewebs-
Muskelgitter

längliche Formen:
Coelomräume

Mundreuse

bewegliche Mundregion

gegliedertes Hydroskelett

Einzeller

Trichoplax

Vendozoen

Ctenophoren

Schwämme

Zilienplatten

sessile Lebensweise

Kanalvermehrung

Skelett

Abflachung

Stromatoporen

Verdauungsräume

Wechsel
Polyp/Meduse

Quallen,
Hydrozoen

Schlundrohr und Mesenterien

Einzelpolypen

~600 million years ago

https://astrobiology.nasa.gov/news/how-did-multicellular-life-evolve/

image: http://www.morphisto.de/

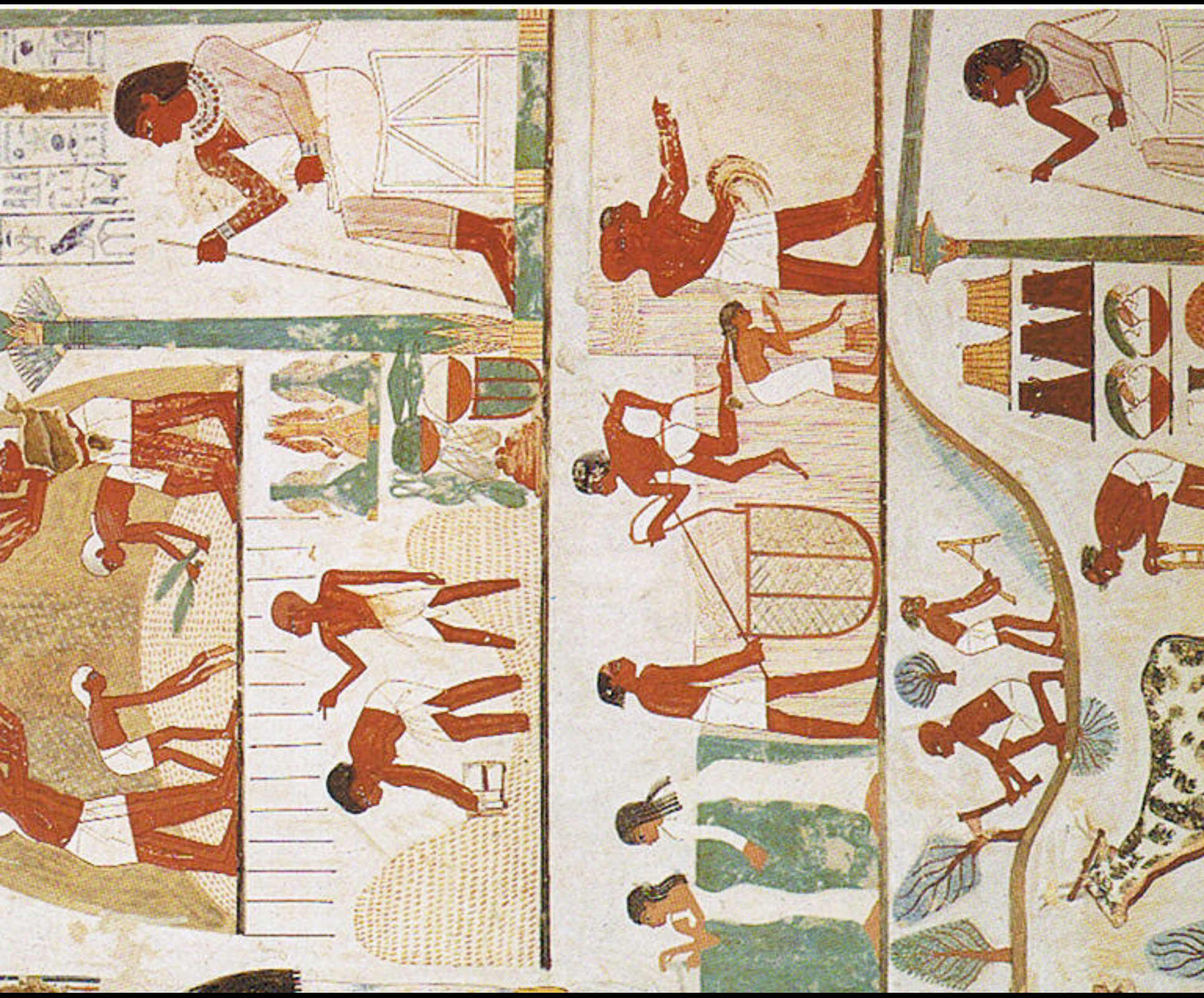
1.7 million - 200,000 years ago

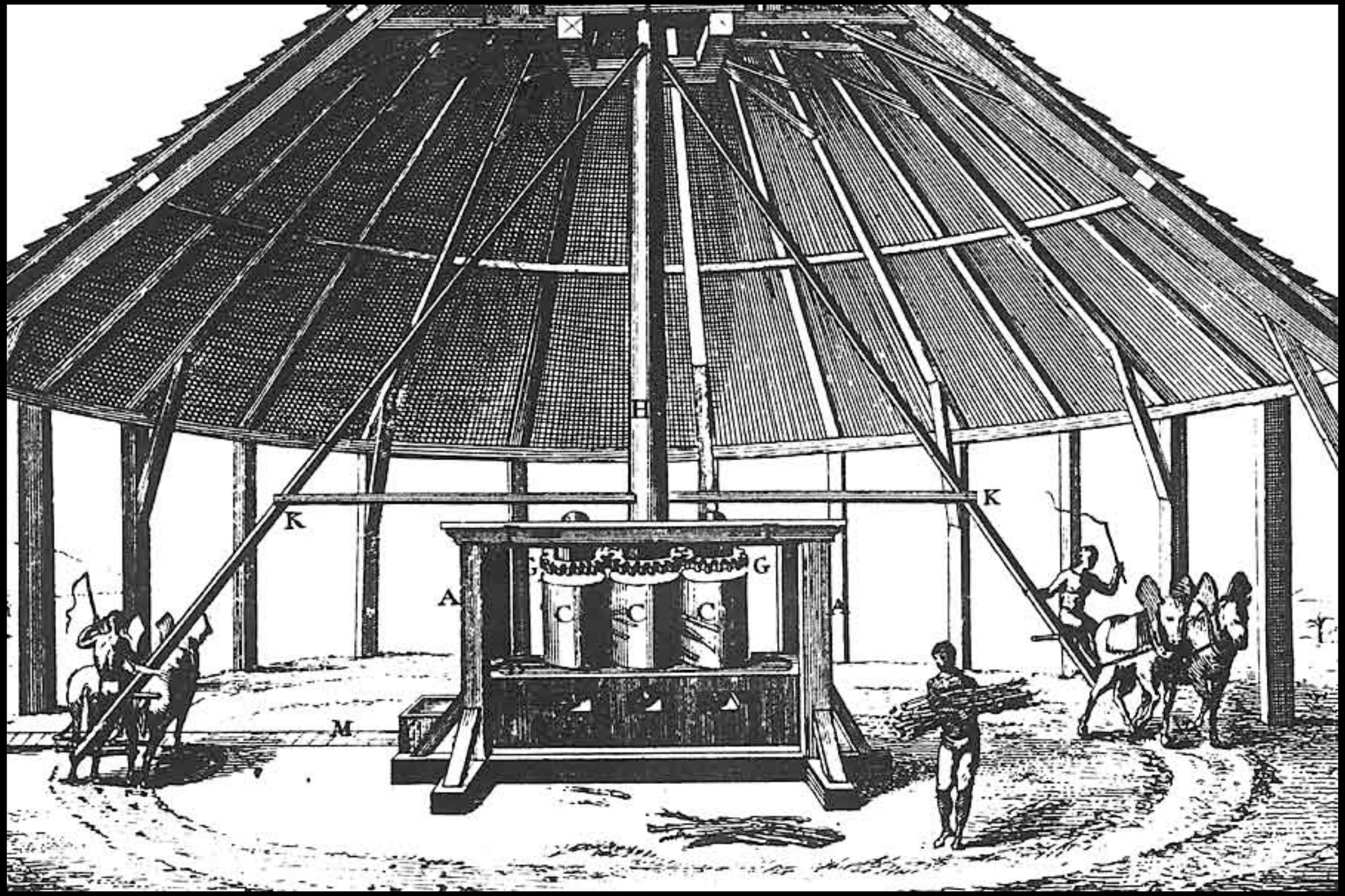
https://www.livescience.com/when-did-humans-discover-fire.html

20,000-30,000 years ago

~10,000 years ago

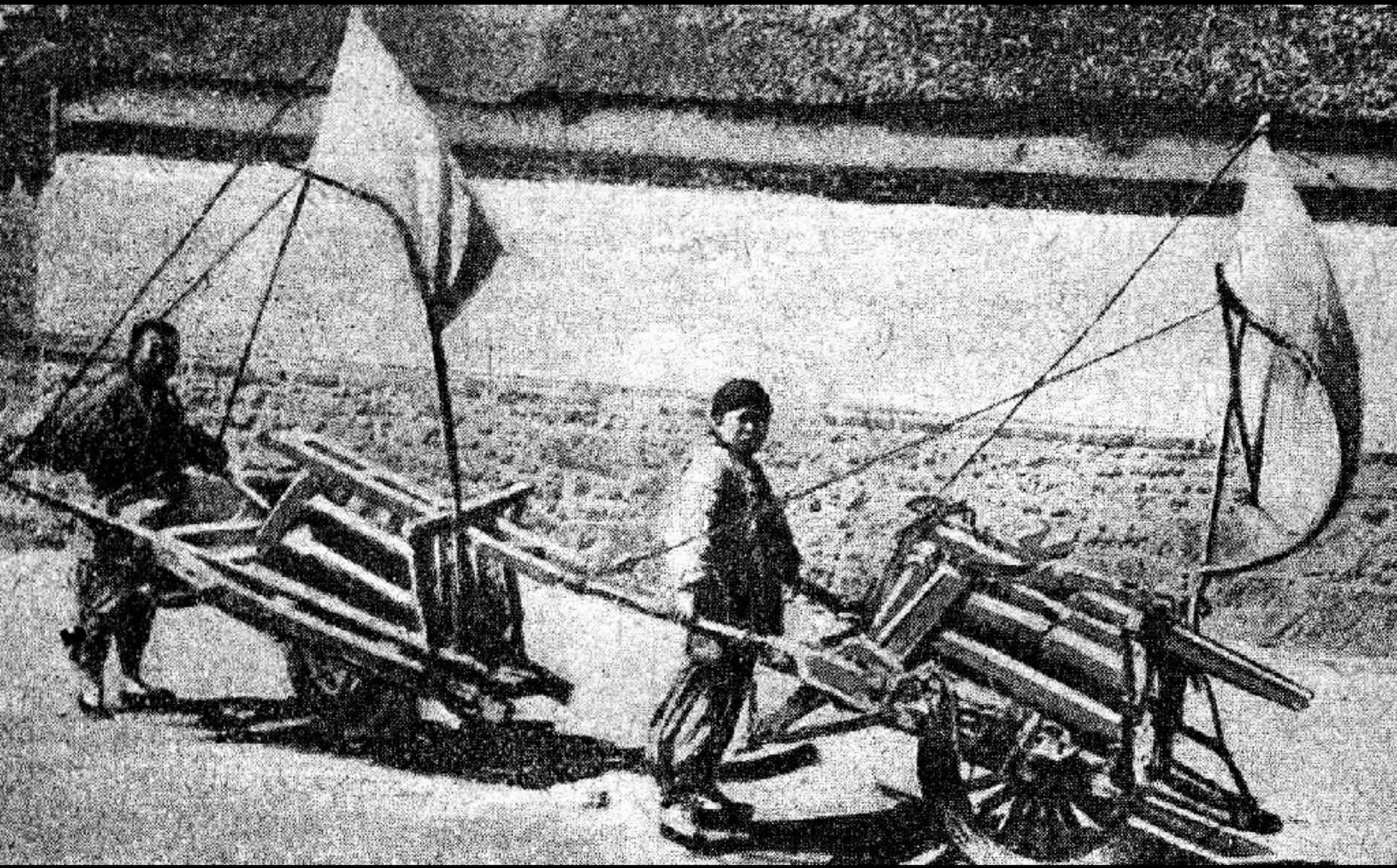
https://www.history.com/topics/pre-history/neolithic-revolution




K
K
H
A
A
C
C
C
G
G
M

~1000 CE

https://www.atlasobscura.com/places/nashtifan-windmills



Stone Age - no fire needed

Bronze Age - 950°C

Iron Age -1500°C

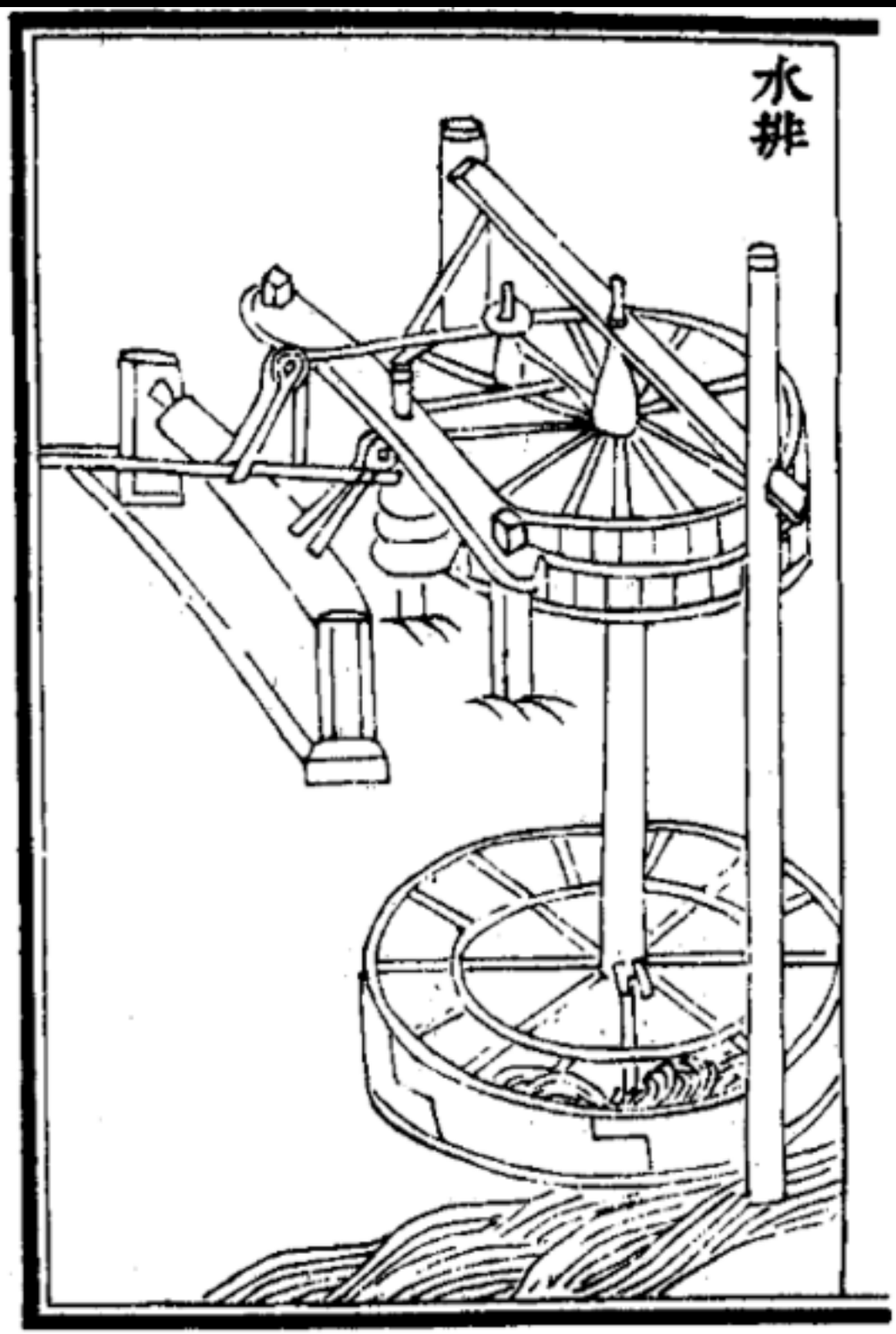


Illustration from Nong Shu (農書) by Wang Zhen (王祯) 1313 CE

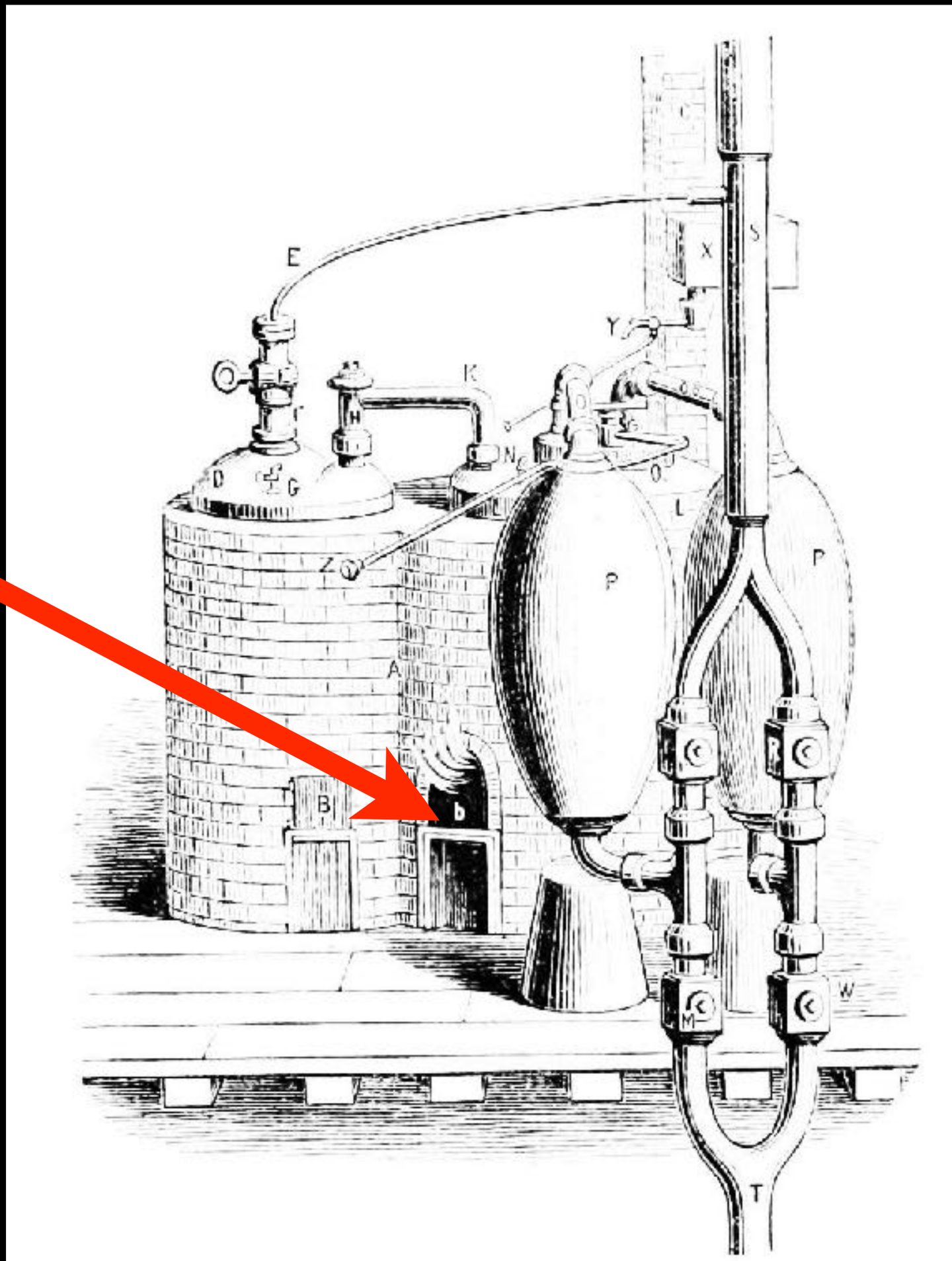
100 BC - Herona (?)

1300s - Huolongjing

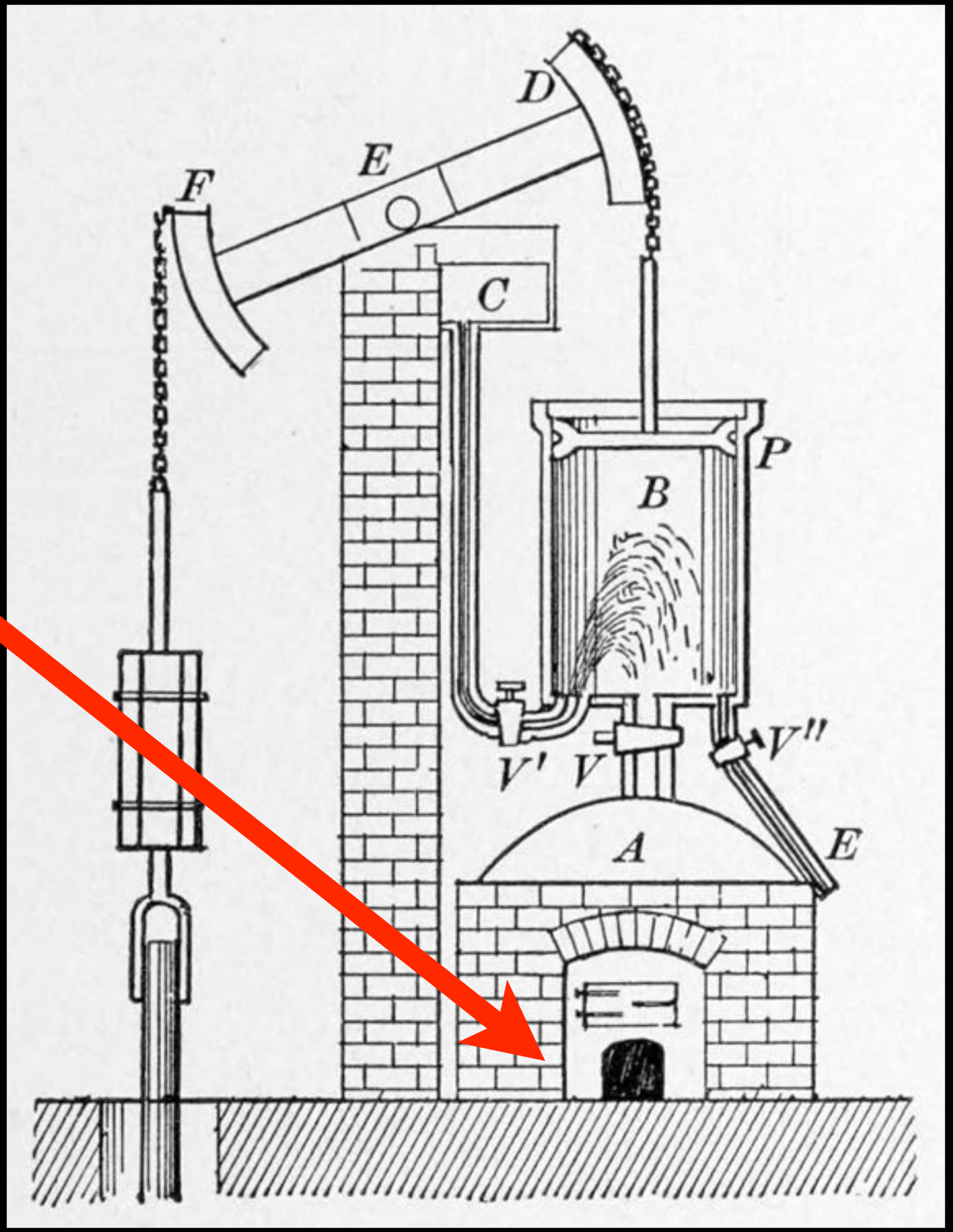
Evidence of coal stores along the length of **Hadrian's Wall** suggests that the Romans learned about coal mining and its uses from the Britons… coal was picked up on beach outcrops at various places … As the supply of coal on the surface was used up, settlers began to dig up the beach to uncover the seam and follow it inland… generally **the seam continued underground, encouraging the settlers to dig to find coal**, and giving birth to coal mining as we know it today.

UK Coal, "Mining Through the Ages"

1698
Thomas Savery's
"Miner's Friend"

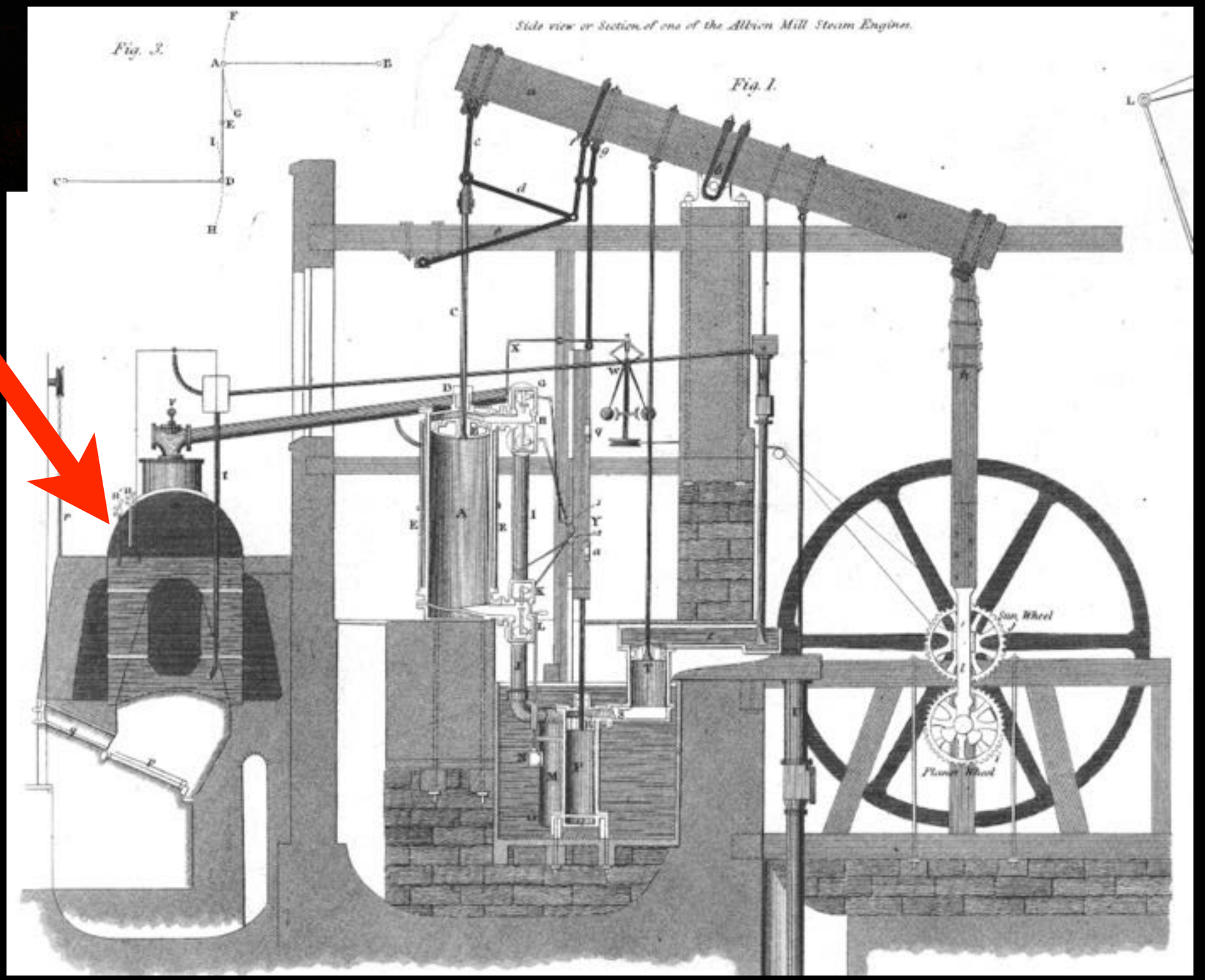


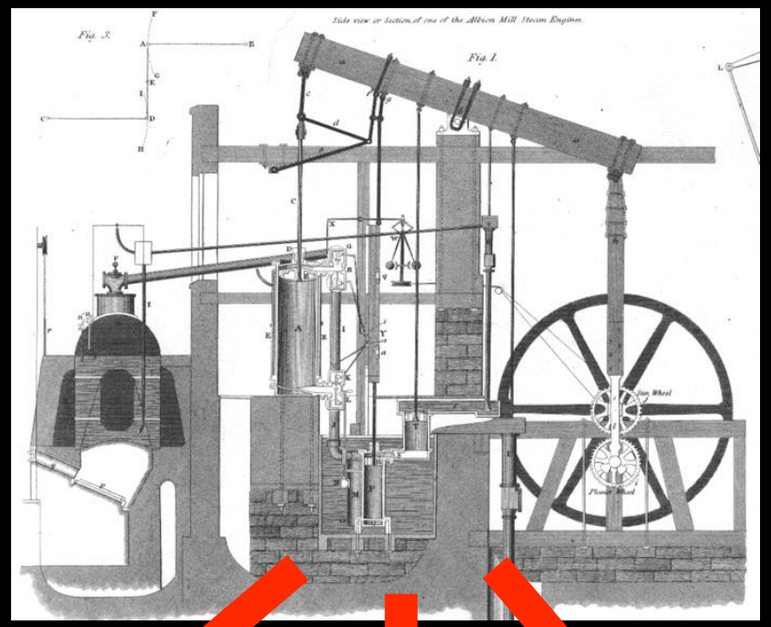
1712
Thomas Newcomen's
"Atmospheric Engine"



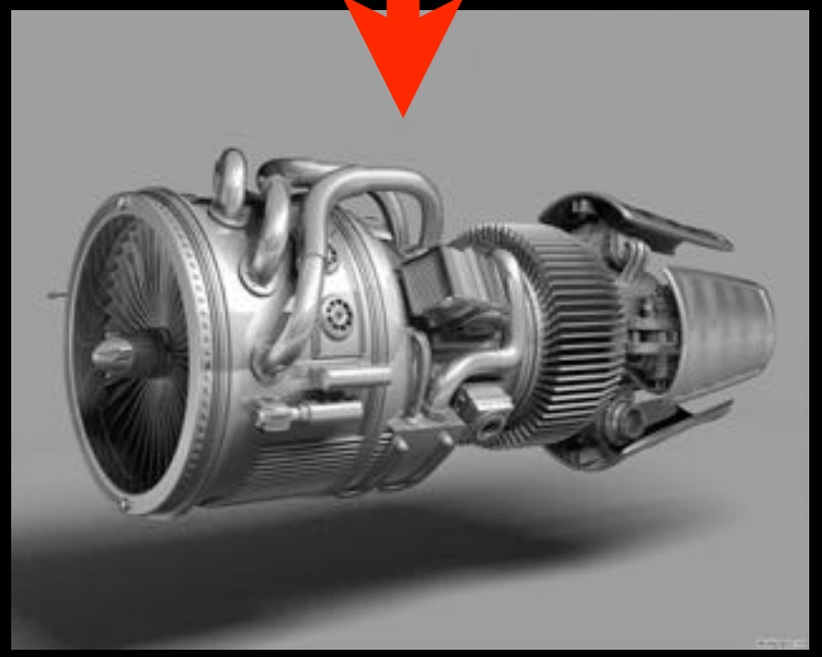
1775
James Watt's
Steam Engine

Mechanized resource extraction powered by the extracted resource

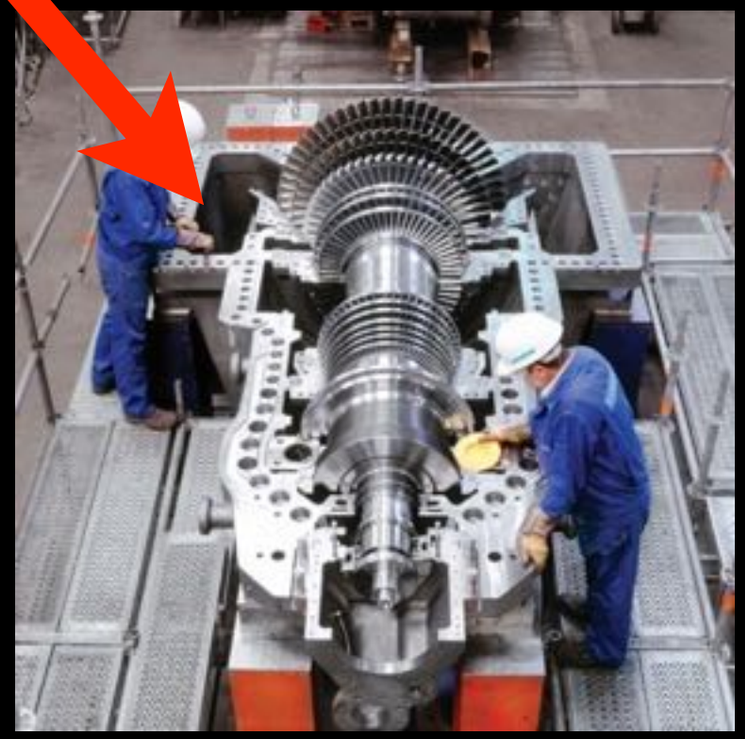




I.C.E.



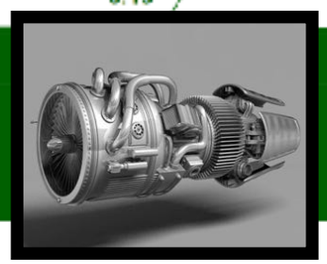
Jet engine



Steam turbine

Estimated U.S. Energy Consumption in 2019: 100.2 Quads

Lawrence Livermore National Laboratory



Source: LLNL March, 2020. Data is based on DOE/EIA MER (2019). 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. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU equivalent values by assuming a typical fossil fuel plant heat rate. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 21% for the transportation sector and 69% 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

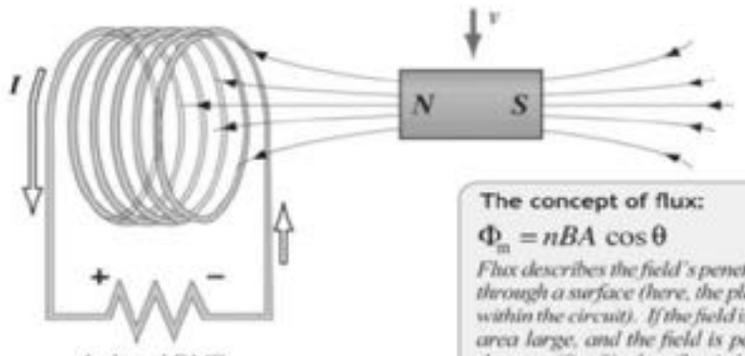
https://flowcharts.llnl.gov/archive.html

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



Induced EMF

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 (θ = 0), then flux is high. Each turn in the coil (n) adds more area.

Image Source: http://wikipremed.com/01physicscards600/379a.gif

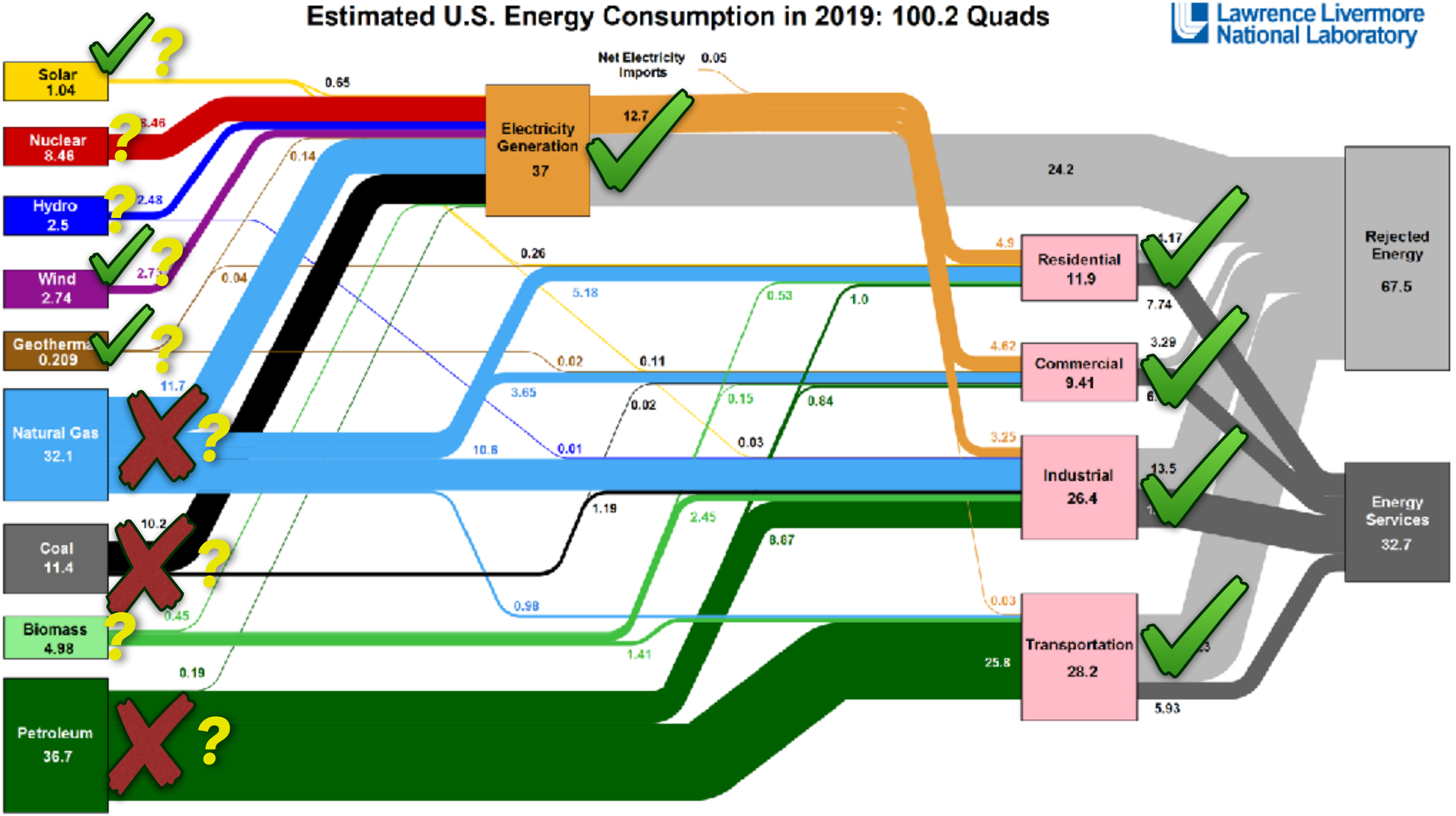
?

Manoj Bhargava

http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/indcur.html

Estimated U.S. Energy Consumption in 2019: 100.2 Quads

Lawrence Livermore National Laboratory



Source: LLNL March, 2020. Data is based on DOE/EIA MER (2019). 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. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU equivalent values by assuming a typical fossil fuel plant heat rate. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential sector, 65% for the commercial sector, 21% for the transportation sector and 69% 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