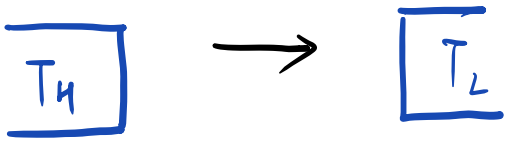
many facets of 2nd Law :

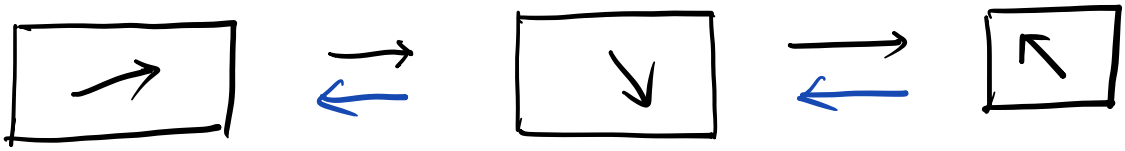
1°

hot cold



heat flow

2°



看上去没有不同

$$\vec{F} = m\vec{a} = m\frac{d^2\vec{r}}{dt^2}$$

$t \to -t$

one particle ⟶ many particles

牛奶散开在咖啡

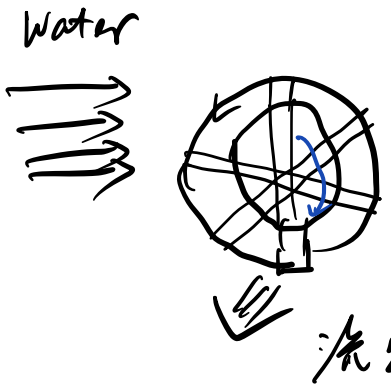
but 没看到牛奶聚拢

{ energy transfer
  information transfer

1712 Newcomen → Steam engine

1763 - 1782 Watt → industrial revolution

Carnot → what is the optimal efficiency of a heat engine ?



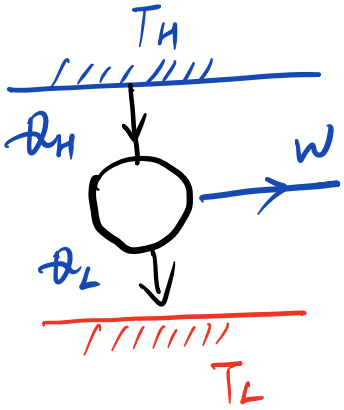
水的重力势能

"水磨" watermill

Water filled at some height

↓↓ → discharged at low level

What a great observation !!



Caloric filled at some high T reservoir

→ discharged into low T

$W = Q_H - Q_L$ (1st law)

(吸) (排)

$$\eta \equiv \frac{W}{Q_H} = 1 - \frac{Q_L}{Q_H} \quad (< 1)$$

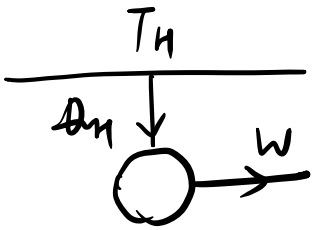


Fig (★)

perfect heat engine :

→ against 2nd law

本行是热力学，不小心成了量子电动 ^v^

Kelvin - Planck statement :

Fig (★) is impossible !

Joule : 1卡 = 4.2 焦耳

功 → 热 （天然莫明呀 ^J^）

反过来，利用做热 → 功，还能建立

热功当量吗 ^^

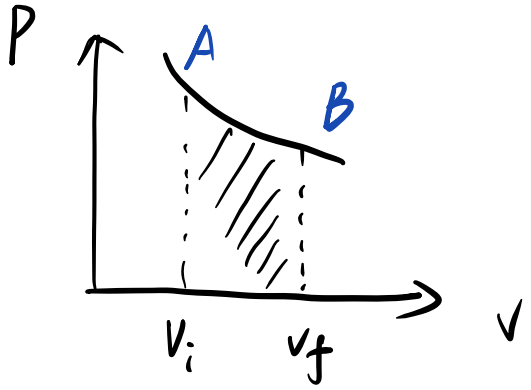
能量的 quality :

直流电 → 交流电

烧煤 → 发电

heat flow diagram → Carnot cycle

"cycle"

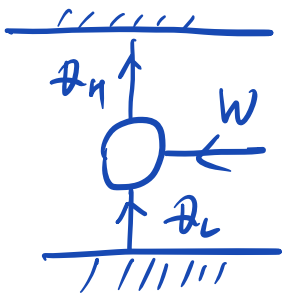


$Q = W$

it is not a cycle !!

把热完全转化为功，but 系统变了！

问题是要循环

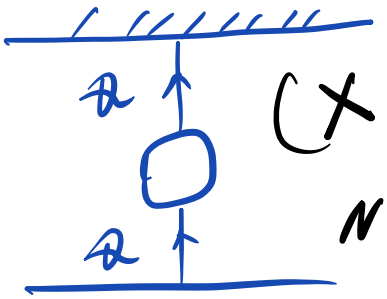


coefficient of performance = cop

$$= \frac{Q_L}{W} = \frac{Q_L}{Q_H - Q_L} = \frac{1}{\frac{Q_H}{Q_L} - 1}$$

冰箱：5

宿舍：2~3



Clausius statement:

(X)

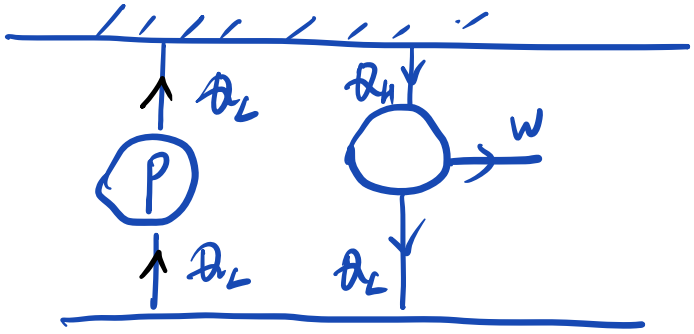
NO "perfect" refrigerator

cop → ∞

K - P statement ≡ C - statement

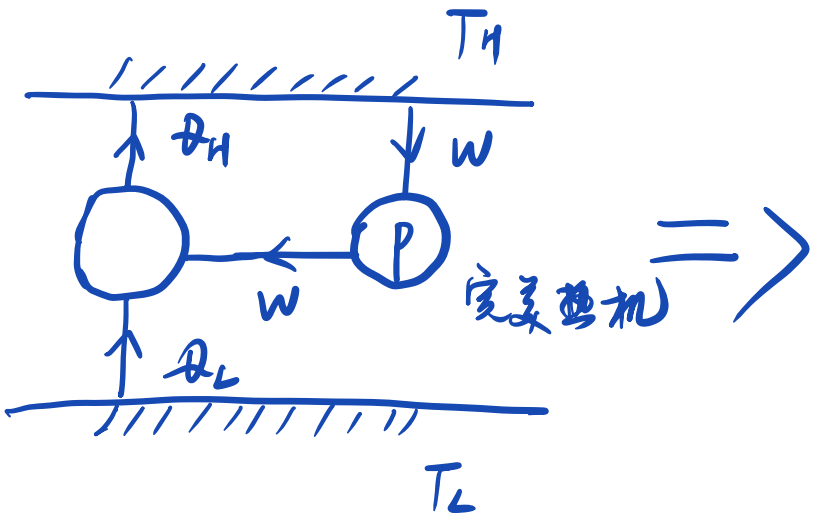
反证法：

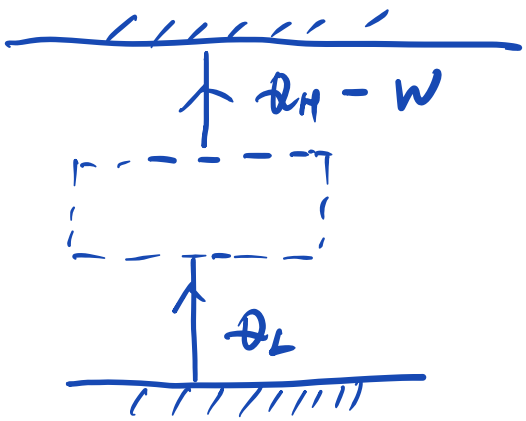
(A) assume Clausius is wrong



完美冰箱 ⇒ 完美热机

(b) assume K-P is wrong





完美热机 ⇒ 完美冰箱

Otto VS Carnot (周期很长)

↓ ↓效率很低，功率很差

1种很多 cycle

细水流大

人生苦短 (水滴石穿但不会用水来穿石，你等不了)

→ otto循环被选为汽车引擎

Carnot theorems:

(A) All revisible heat engine working between T_H & T_L have the same efficiency

(B) no heat engine is better than Carnot engine.

ideal engine is not perfect engine

科学告诉我们你造不出完美机

不完美不是因为什么摩擦力之类的

东西，Q，T，S 以这种形式

实现做功伴随"能量质量"的问题

即做功的能力的问题。

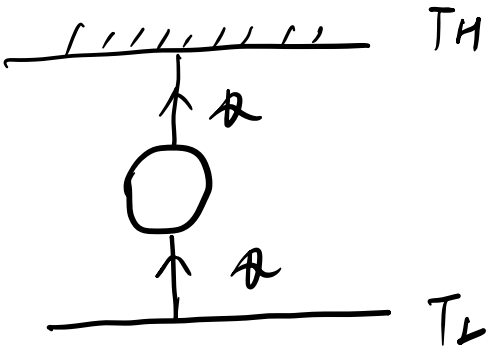
/'gæsəli:n/ 汽油机

Realistic gasoline engine:

$\eta \sim 20\%$

diesel engine: 柴油机

/'di:zl/ $\eta \sim 30\%$ 内燃机



perfect R

impossible

如果发生：

（吸热为正）

$$-\frac{Q}{T_L}+\frac{Q}{T_H}+W<0$$

（cycle：状态参量S变）

$$\Delta S<0$$

但是不可能 → 描述实际过程

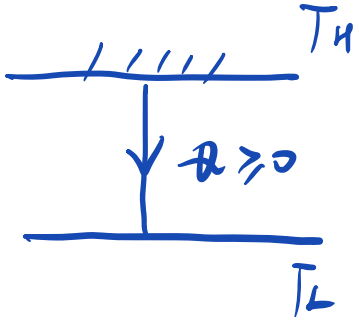
2nd Law Clausius statement

→ NO perfect refrigerator

⇓

$\Delta S \geq 0$ （熵增原理）

能发生的过程：



$$-\frac{Q}{T_H}+\frac{Q}{T_L}\geq 0$$

学习是减熵过程：

答是非题，没学，可是可非

学了，这是求非

在熵的意义上并无差别

学得好与不好，S 无差

学与不学，S 差很大