ENTROPY "AS"

IRREVERSIBILITY

DISORDER

(LACK OF) INFORMATION

"IGNORANCE"

CARNOT ENGINE

≡ REVERSIBLE ENGINE

↳ STRICT SENSE : SYSTEM ARE REV.

CARNOT'S INSIGHT : MAX. EFFICIENCY OF A HEAT ENGINE REQUIRES REVERSABILITY.

⇒ HEAT TRANSFER ONLY AT CONSTANT T.

$$\underset{①}{\boxed{T+dT}} \xrightarrow{Q} \underset{②}{\boxed{T}}$$

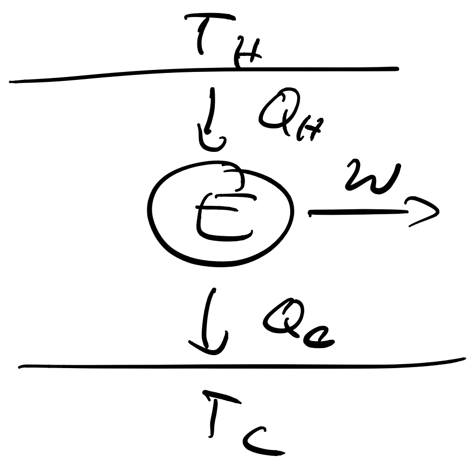
$$\Rightarrow \frac{Q_1}{T_1} + \frac{Q_2}{T_2} = -\frac{Q}{T+dT} + \frac{Q}{T}$$

$$= \frac{Q}{T}\left(\frac{-1}{1+\frac{dT}{T}} + 1\right) \simeq \frac{Q}{T}\left(1 - \left(1 - \frac{dT}{T}\right)\right)$$

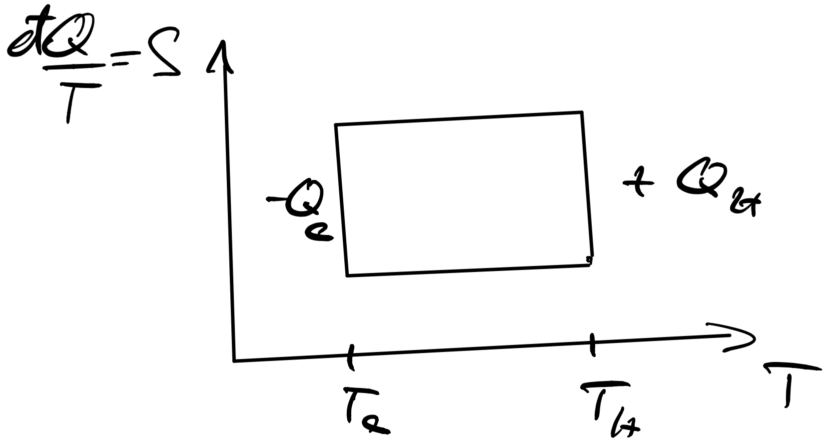
$$= 0 + \text{Order}\left(\frac{dT}{T}\right)$$

SIMPLIFIED DIAGRAM

(NO INTERNAL SPECIFIED)



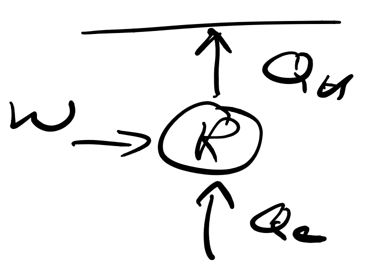
REVERSIBLE ENGINE CYCLE IN S-T DIAGRAM



DIRECTION

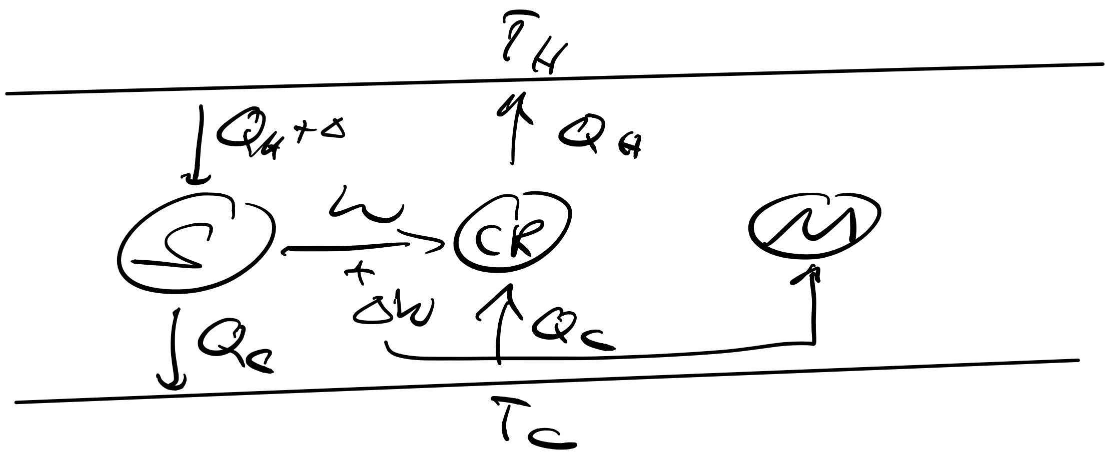
$$\eta = \frac{W}{Q_H} = \frac{Q_H - Q_C}{Q_H} = 1 - \frac{Q_C}{Q_H}$$

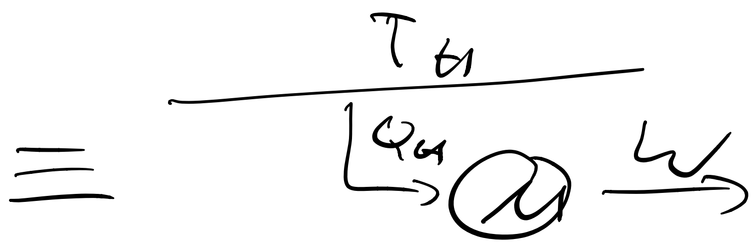
CARNOT IN REVERSE → REFRIGERATOR



T_c

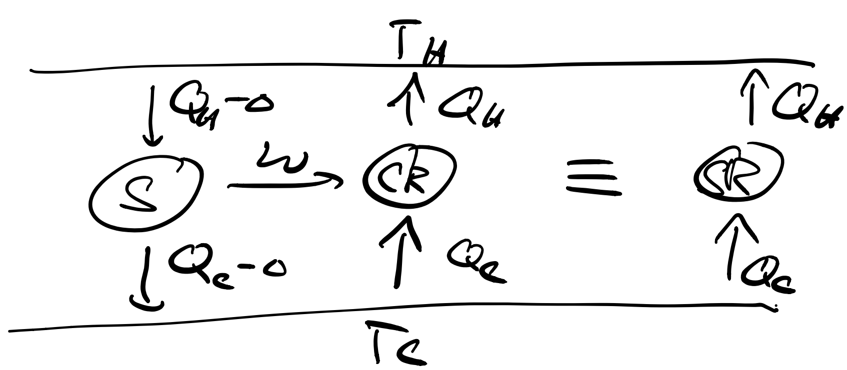
ASSUME A MORE EFFICIENT "SUPER" ENGINE → USE IT TO POWER A CARNOT FRIDGE.





KELVIN vs of 2ND LAW:

NO PROCESS IS POSSIBLE THAT SOLELY CONVERTS HEAT INTO WORK.



4) CLAUSIUS

NO PROCESS IS POSSIBLE THAT ONLY TRANSFERS HEAT FROM A COLD TO A HOT RESERVOIR.

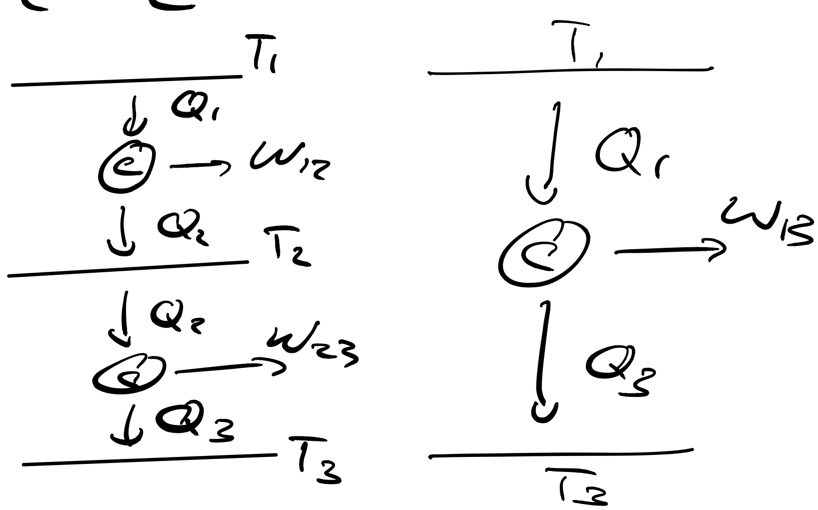
→ COROLLARY: CARNOT ENGINE IS MOST EFFICIENT ENGINE

$\eta_C \geq \eta_{\text{non CARNOT}}$

EPLICITLY CALCULATE η_C FOR ONE REALIZATION, FOR EXAMPLE PISTON WITH IDEAL GAS. → SEE BOOK CH 5

EFFICIENCY OF CARNOT ENGINE CAN ONLY DEPEND ON T_C, T_H (THE ONLY PARAMETERS OF THE PROBLEM)

$\eta_C = \eta(T_H, T_C)$



$\eta(T_1, T_2)$
$\parallel$

$$Q_2 = Q_1 - W_{12} = Q_1(1 - \eta(1,2))$$

$$Q_3 = Q_2 - W_{23} = Q_2(1 - \eta(2,3))$$

$$= Q_1(1-\eta(1,2))(1-\eta(2,3))$$

$$Q_3 = Q_1 - W_{13} = Q_1(1 - \eta(1,3))$$

$$\Longrightarrow$$

$$1 - \eta(1,3) = (1-\eta(1,2))(1-\eta(2,3))$$

SOLUTION IF $\eta(T_c, T_H) = 1 - \dfrac{f(T_c)}{f(T_H)}$

$$\frac{f(T_3)}{f(T_1)} = \frac{\cancel{f(T_2)}}{f(T_1)} \cdot \frac{f(T_3)}{\cancel{f(T_2)}} \quad \square$$

CHOOSE $f(T) = T$

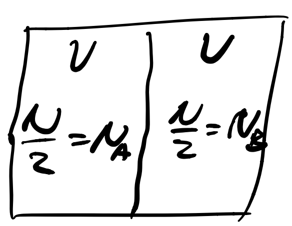
$\rightarrow$ DEFINES TEMPERATURE SCALE IN TD.

$$\Longrightarrow \eta_c = 1 - \frac{T_c}{T_H}$$

ENTROPY OF MIXING

N_A A ATOMS (IDEAL GAS)
N_B B ATOMS

UNMIXED



$$S_{\text{UNMIXED}} = S_u$$

$$= k_B \ln \Omega = k_B \ln \Omega_A + k_B \ln \Omega_B$$

$$= k_B \left(\ln \frac{V^{N_A}}{N_A!} + \ln \frac{V^{N_B}}{N_B!} \right)$$

$$S_U = 2k_B \ln \frac{V^{N/2}}{\left(\frac{N}{2}\right)!}$$

MIXED

$2V$

$N = N_A + N_B$

$$S_{MIXED} = S_M = 2k_B \ln \frac{(2V)^{N/2}}{\left(\frac{N}{2}\right)!}$$

"START WITH S_U AND $V \to 2V$"

$$\Delta S = S_M - S_U = 2k_B\left(\ln (2V)^{N/2} - \ln (V)^{N/2}\right) = 2k_B \ln (2)^{N/2}$$

$$\Delta S = N k_B \ln 2$$

INTERPRET MIXING IN TERMS IRREVERSIBILITY AND IGNORANCE.

<u>IRREVERSIBILITY</u>. ANY STATE WITH "INCREASED" ORDER (I.E. MORE A ATOM IN LEFT HALF AND MORE B ATOMS IN RIGHT) APPEARS AS INCREASINGLY RARE FLUCTUATIONS.

$\propto \frac{1}{\sqrt{N}} \longrightarrow N_A N_B$

IGNORANCE: EVERY TIME YOU PLACE AN ATOM IN ONE OF THE TWO HALVES, WITHOUT LOOKING YOU 'GAIN' $k_B \ln 2$ IN ENTROPY.

WHAT IF $A = B$ $\rightarrow$ $0S$