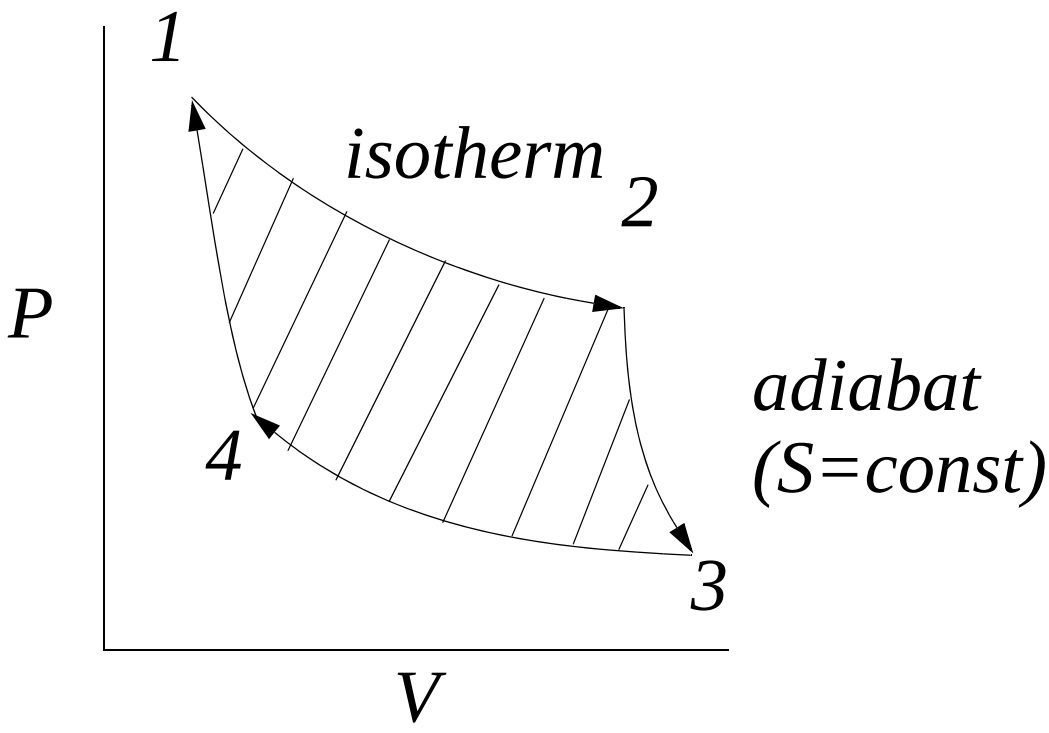
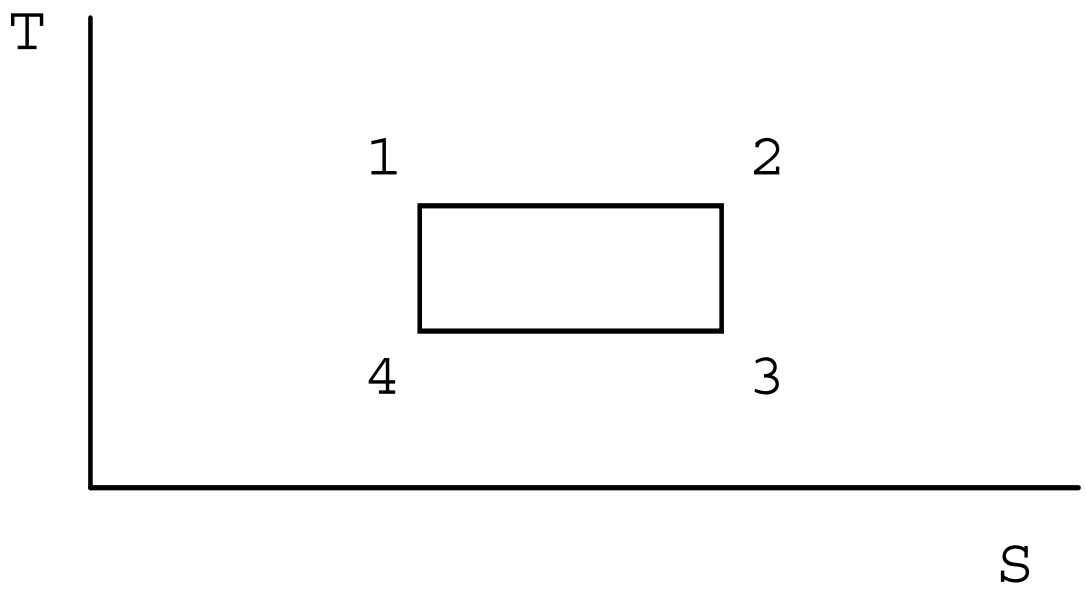
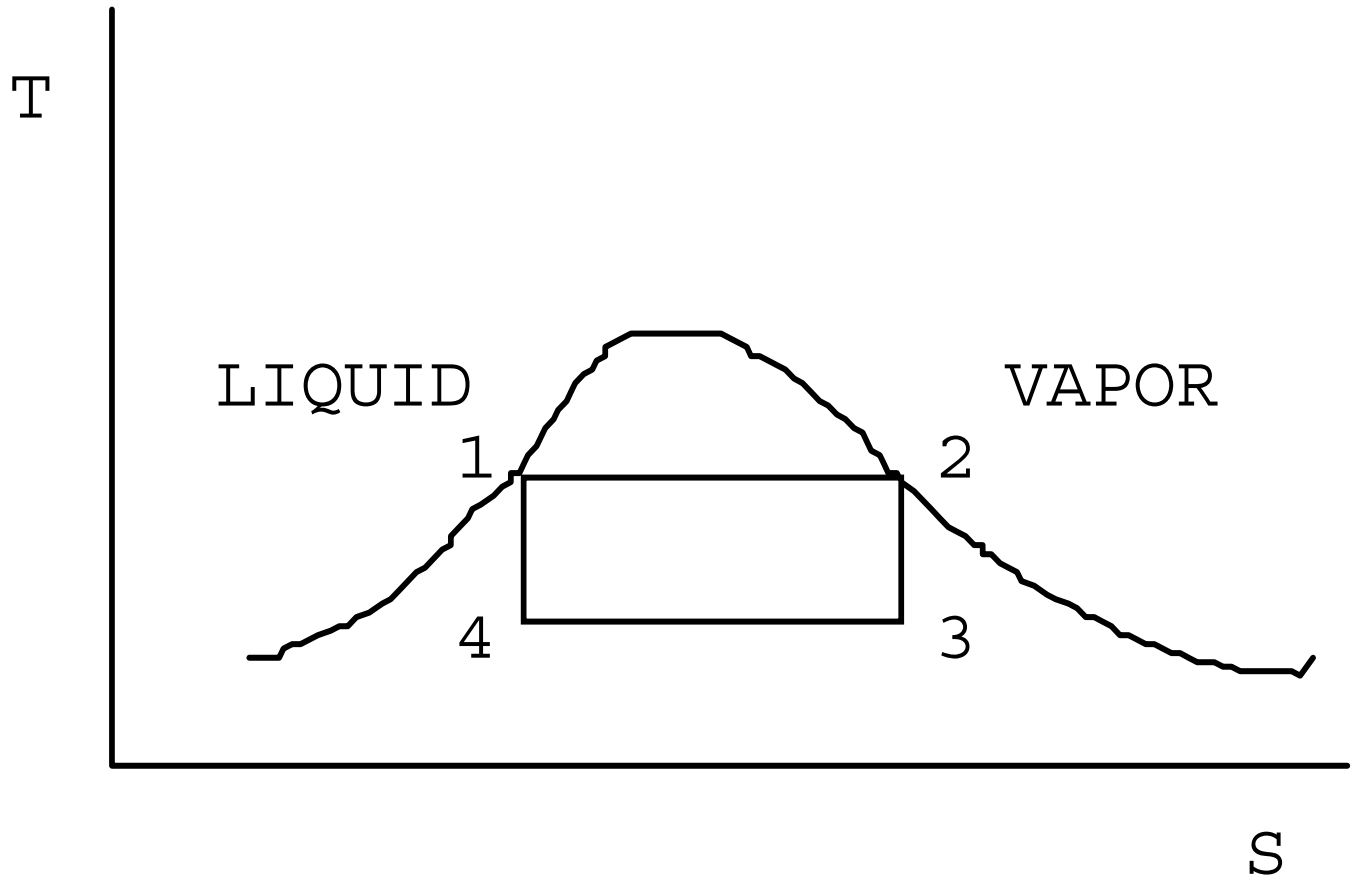
Chapter 4

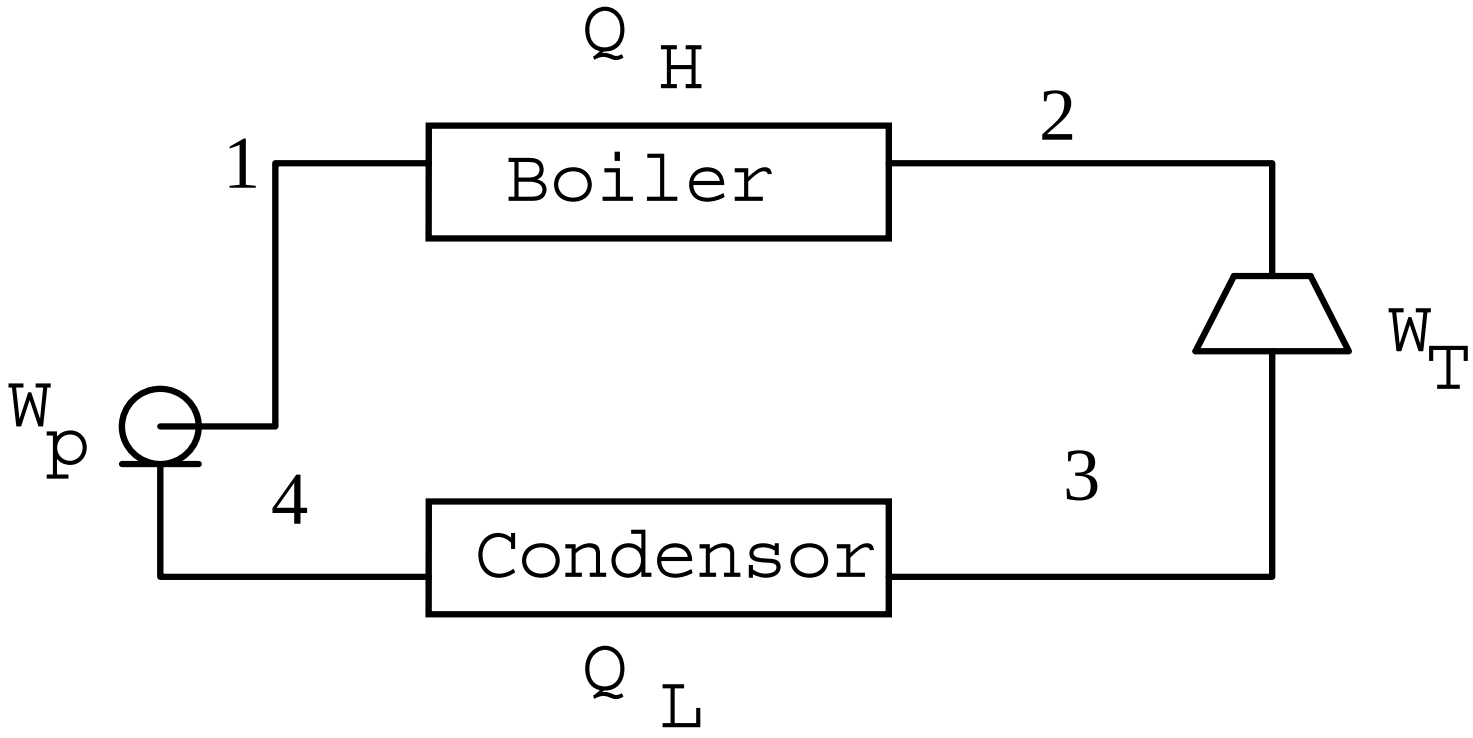
- 4.1-4.2 Steam Carnot and Rankine Cycles
- 4.3 Steam Power Plants
- 4.4-4.5 Refrigeration
- 4.6 Liquefaction
- 4.7 Multistage Compression

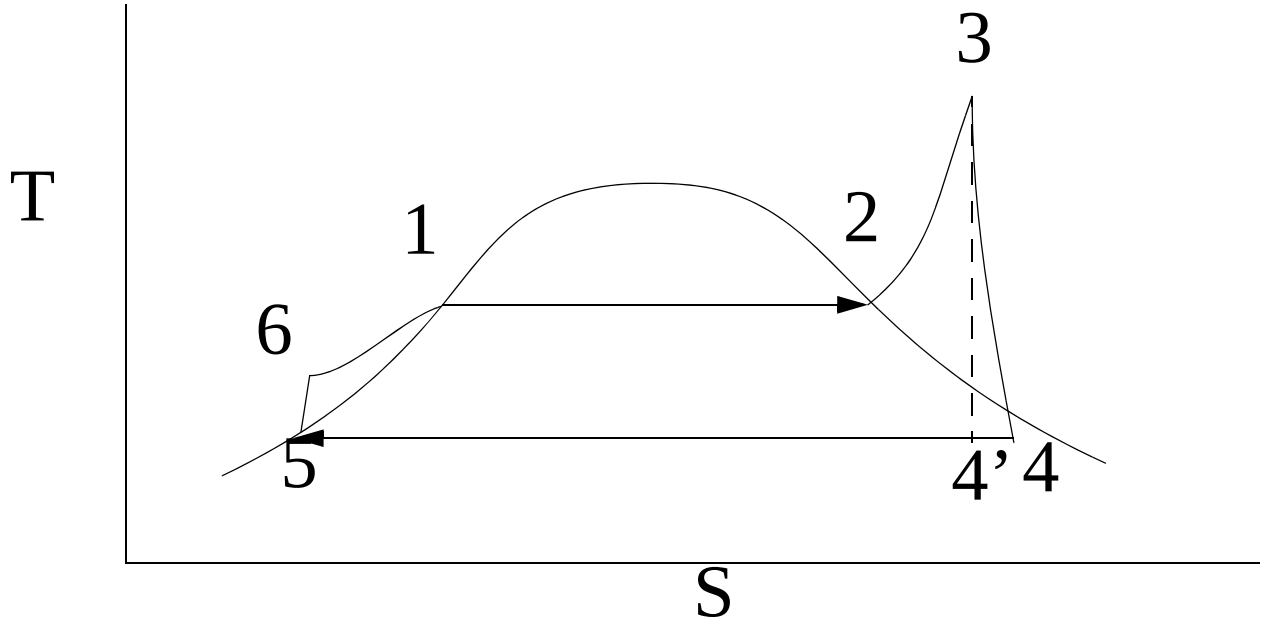

1
isotherm
2
P
adiabat
(S=const)
4
3
V



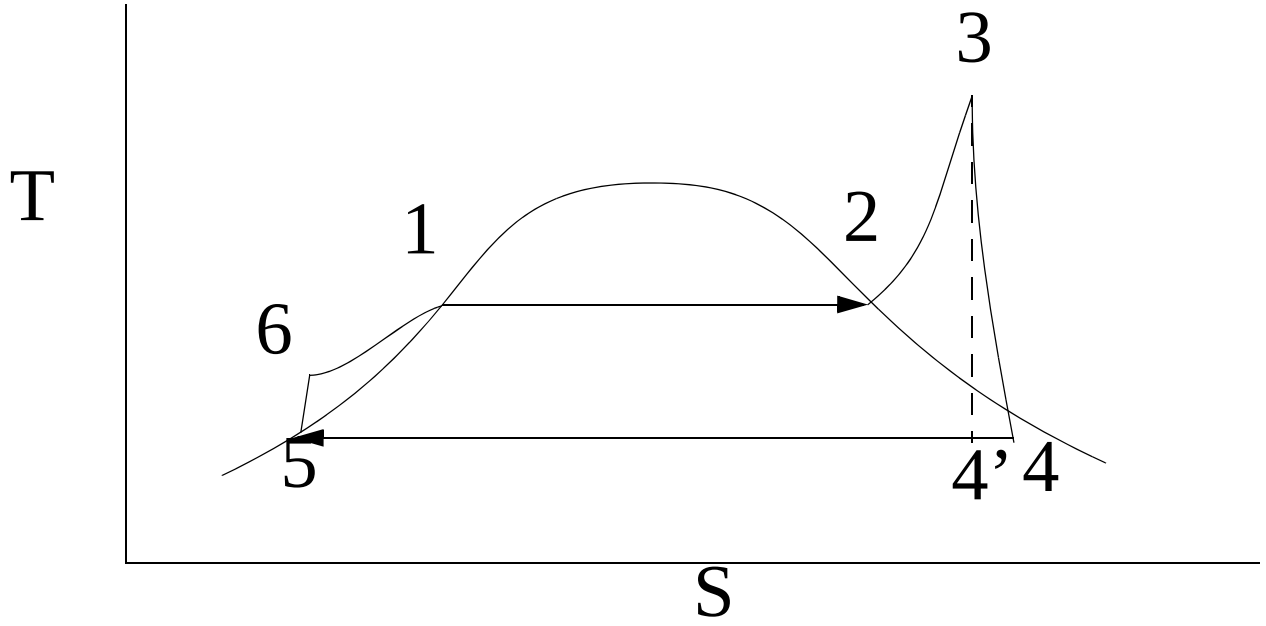
One way to isothermally increase entropy with lots of heat transfer is with phase change:

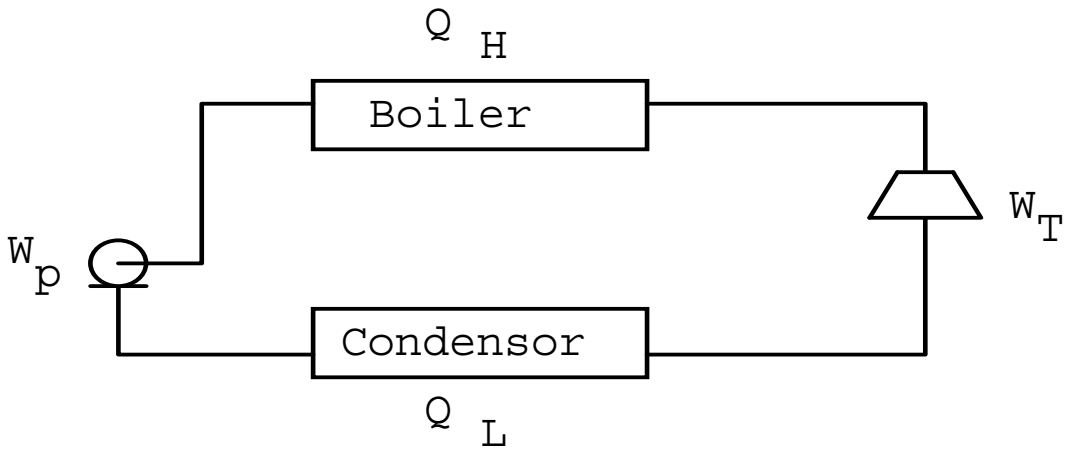

T
LIQUID
VAPOR
1
2
4
3
S


Q H
1
Boiler
2
W T
W p
4
3
Condensor
Q L

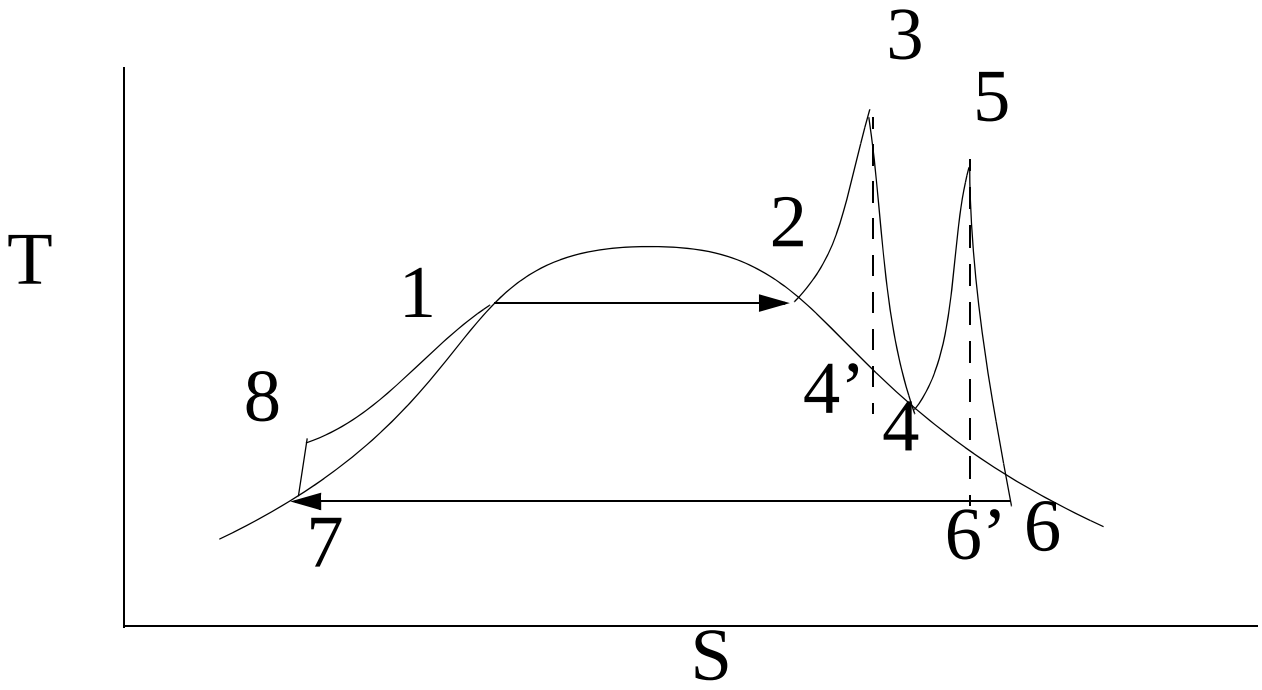

T
S
1
2
3
4’
4
5
6

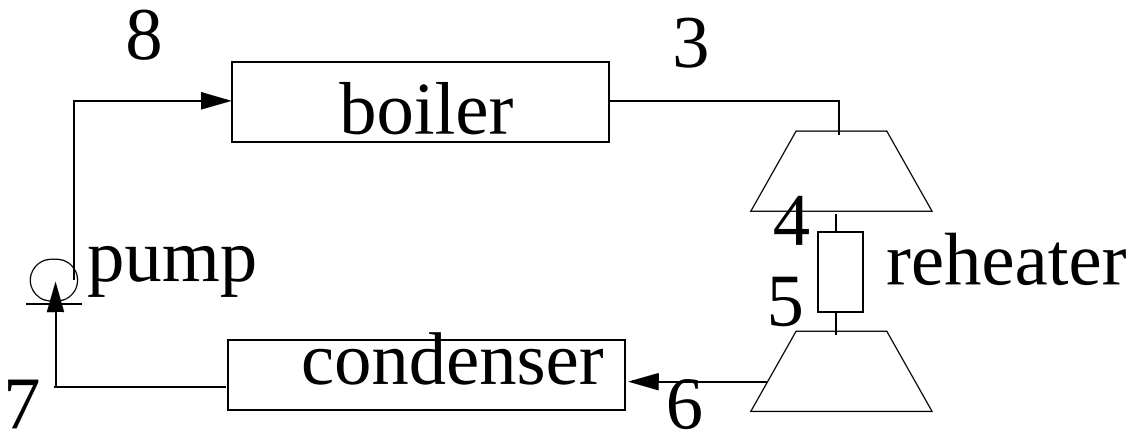
Rankine Cycle (to get more work -- raise T_3?)





Rankine with Reheat (boiler T about same, higher P)





Example 4.3 Rankine with Reheat

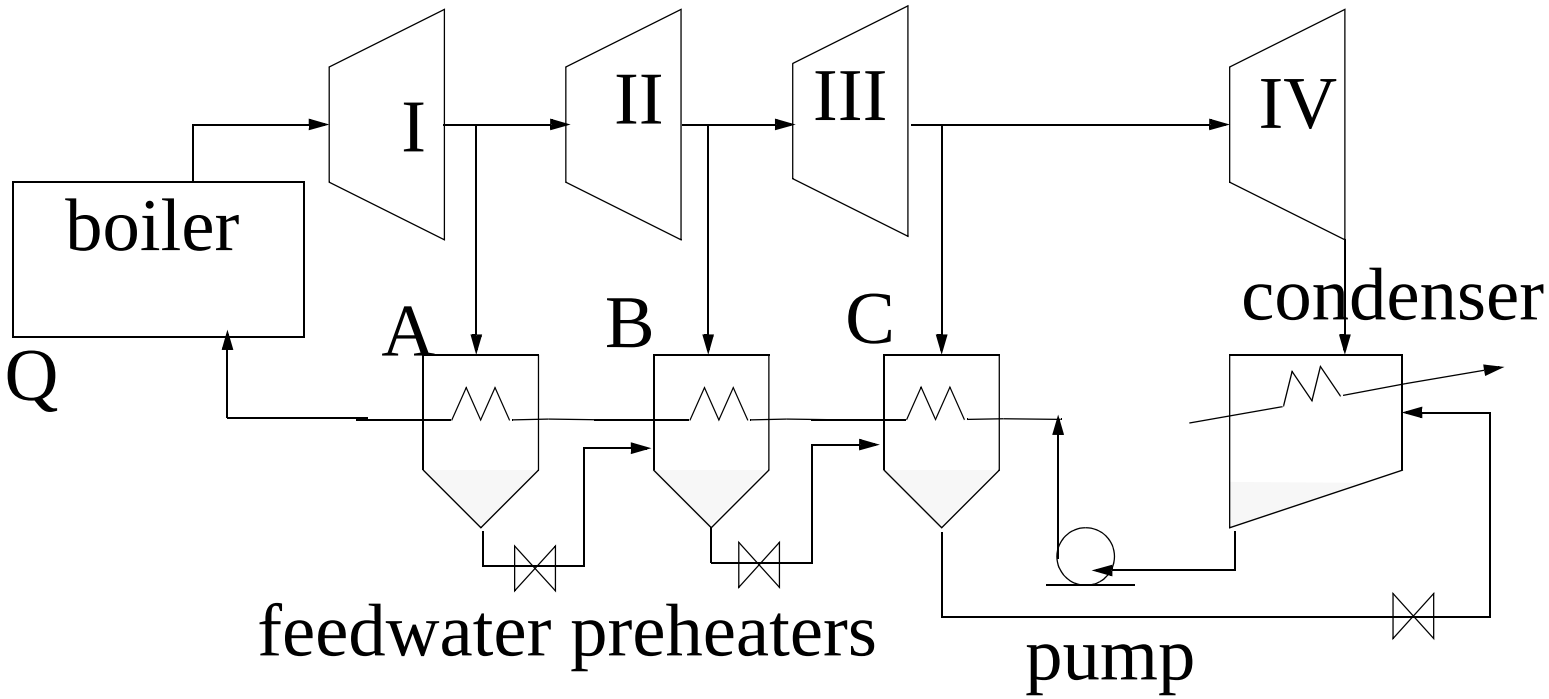
- Boiler limited to 500^{o}C (same as Ex. 4.1, $\eta = 0.27$, $\dot{m} = 4181 \frac{\text{kg}}{\text{h}}$)
- Let feed to second stage be same as Ex. 4.1 (0.8 MPa, 500^{o}C), outlet satV at 0.025 MPa.
- Feed to first stage 434^{o}C and 6 MPa. (7-8 times higher than Ex. 4.2!), exit at 0.8 MPa.
- Reversible turbines

Sketch T-S diagram to visualize states.

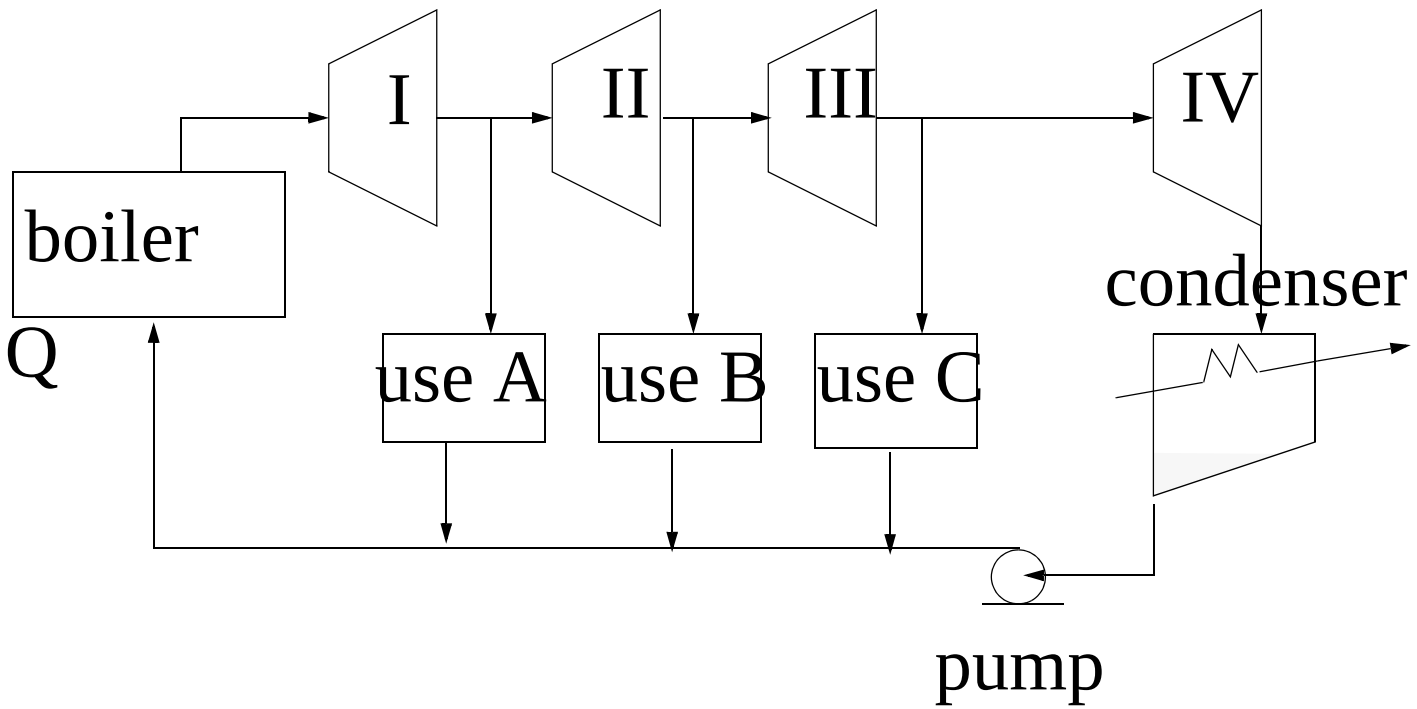
Now, suppose turbines 80% efficient, operating between same pressures. Choose T_3 = 500^{o}C, 6 MPa, T_5 = 500^{o}C, 0.8 MPa. What is ΔH for each turbine?

What $\dot{Q}_{\text{reheater}}$ is required if $\dot{m}$ = 2656 kg/h?

Regenerative Rankine Cycle (Feedwater Preheaters)



Cogeneration



4.4 Refrigeration

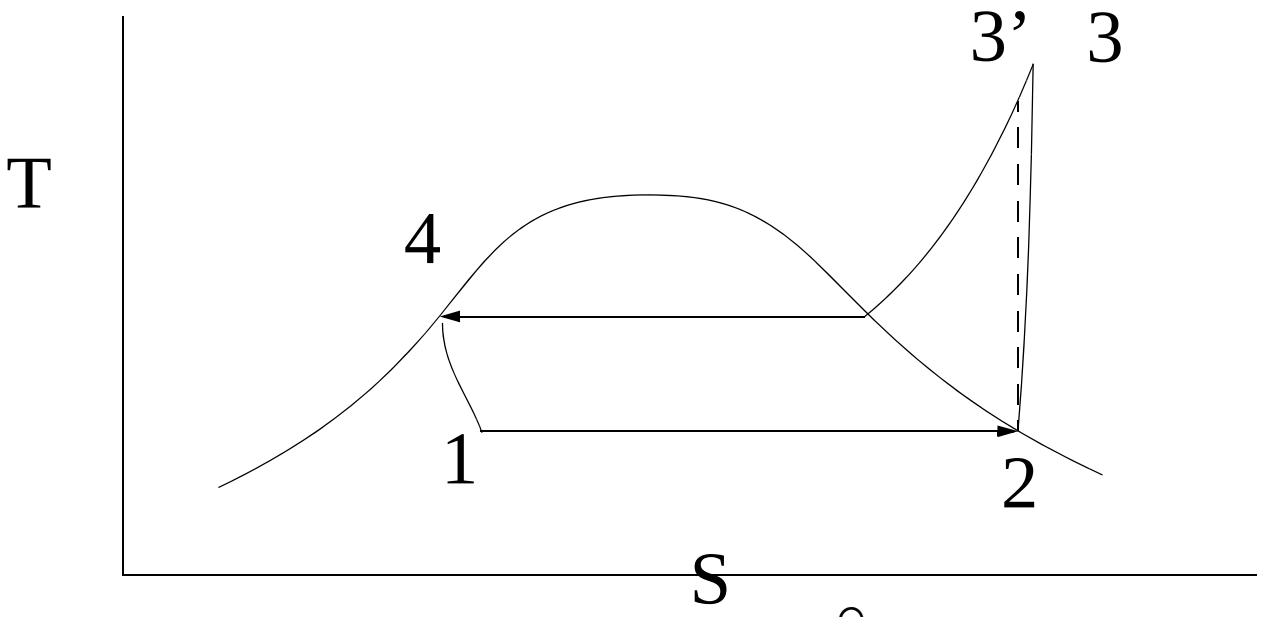
Maximum COP

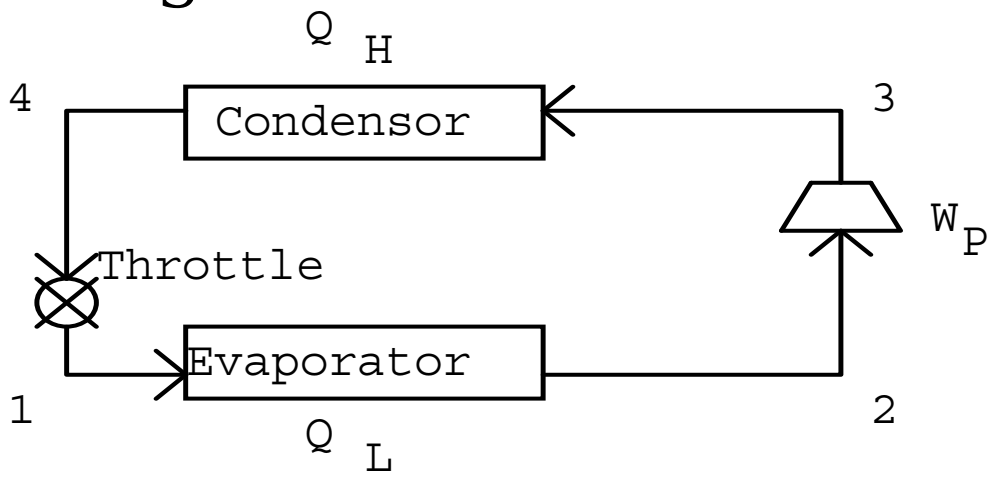
For a Carnot cycle, we already have the necessary formula:

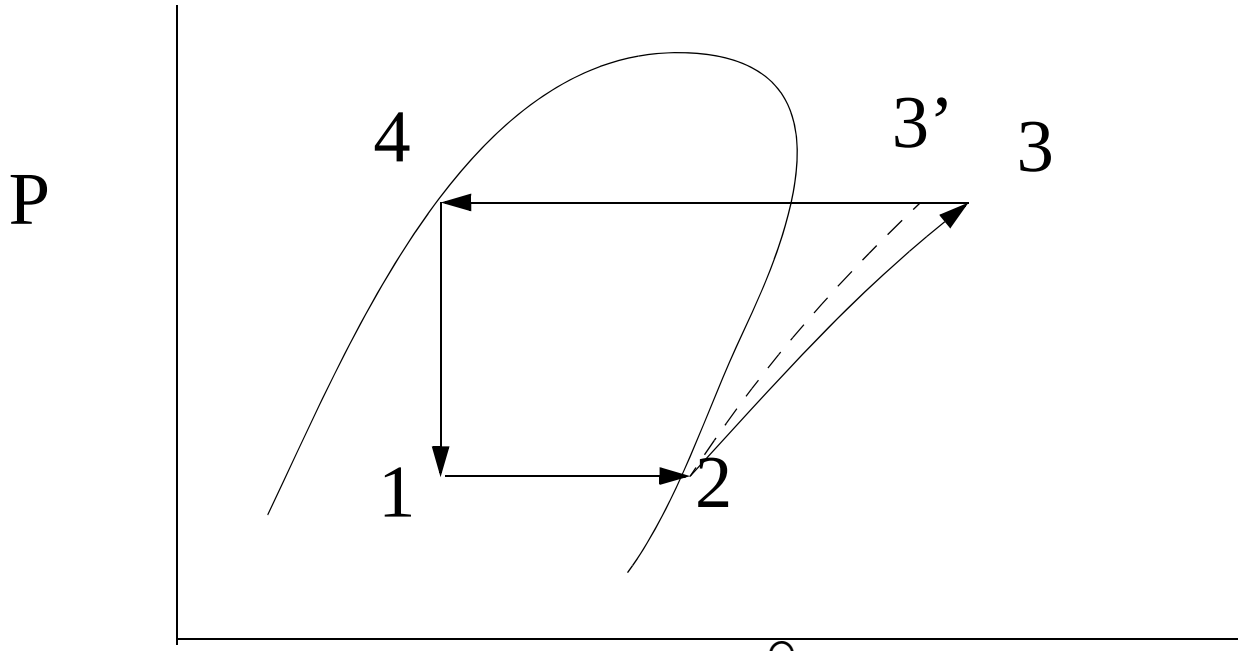
$$\text{COP} = \frac{\dot{Q}_C}{\dot{W}_{net}} \Rightarrow$$

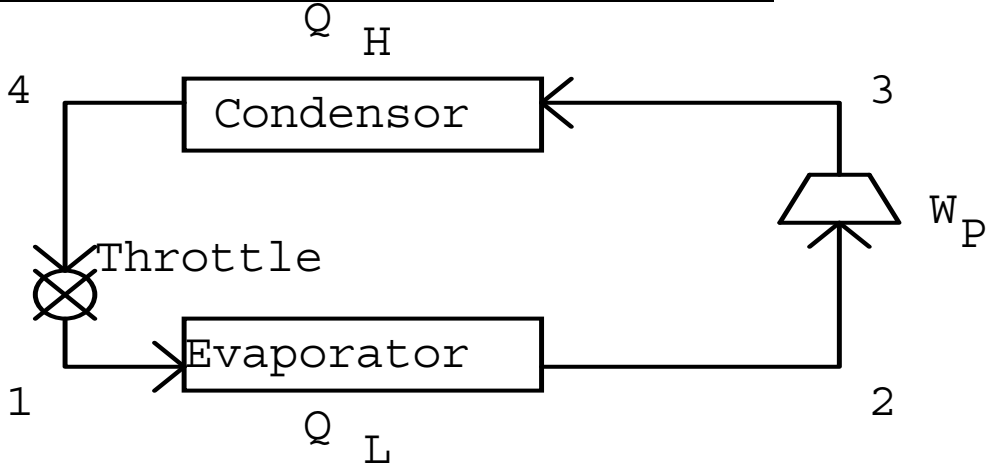
$$\text{For Carnot: COP} = \left(\frac{T_H}{T_C} - 1\right)^{-1}$$

OVC cycle



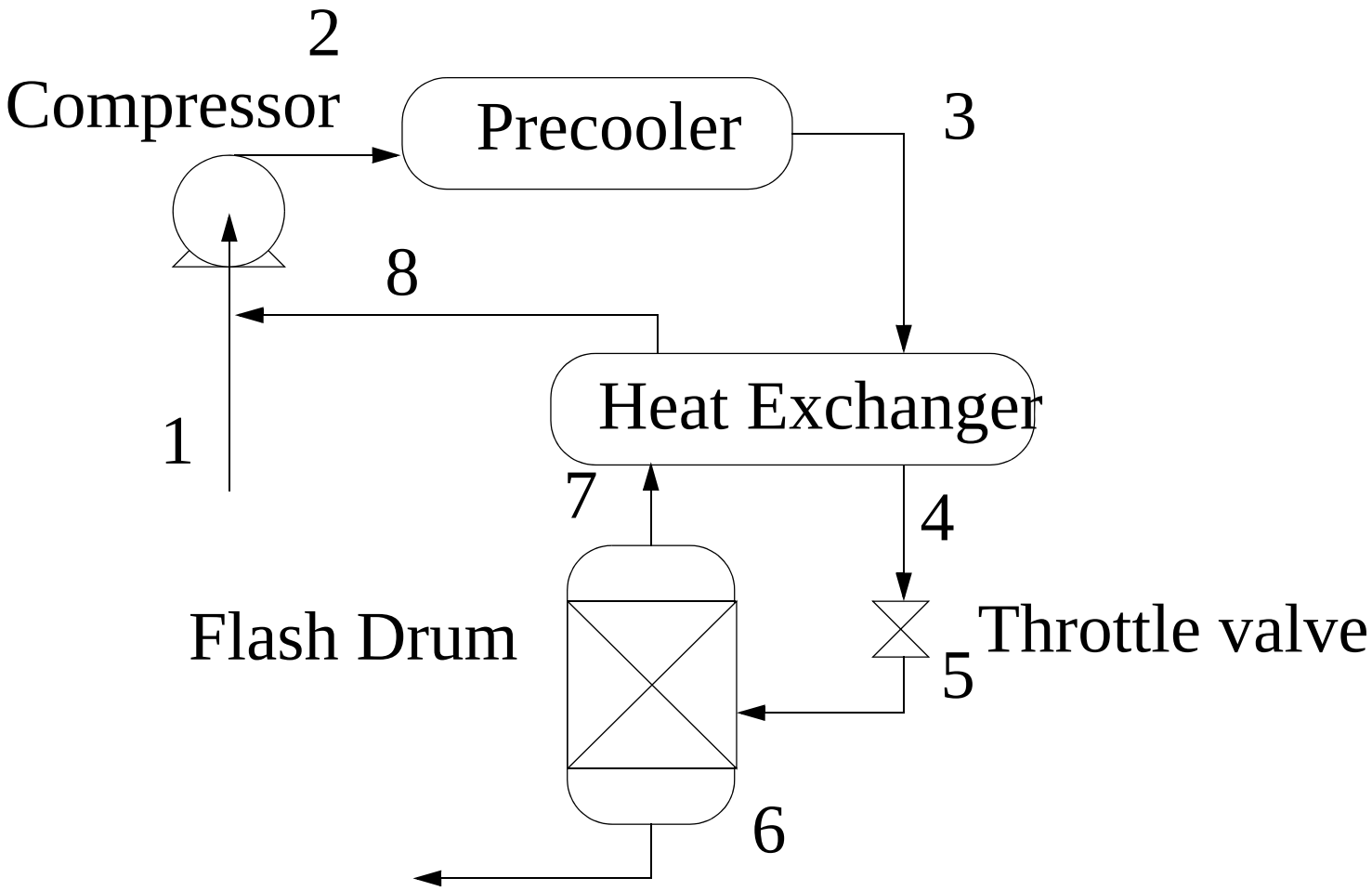



P
4
3'
3
1
2
H

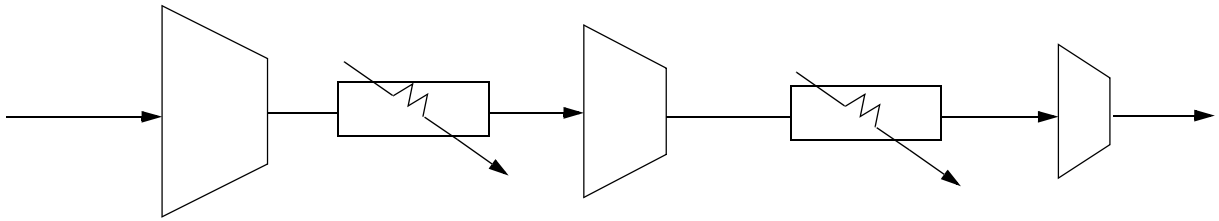

Q H
4
Condensor
3
W P
Throttle
Evaporator
1
2
Q L

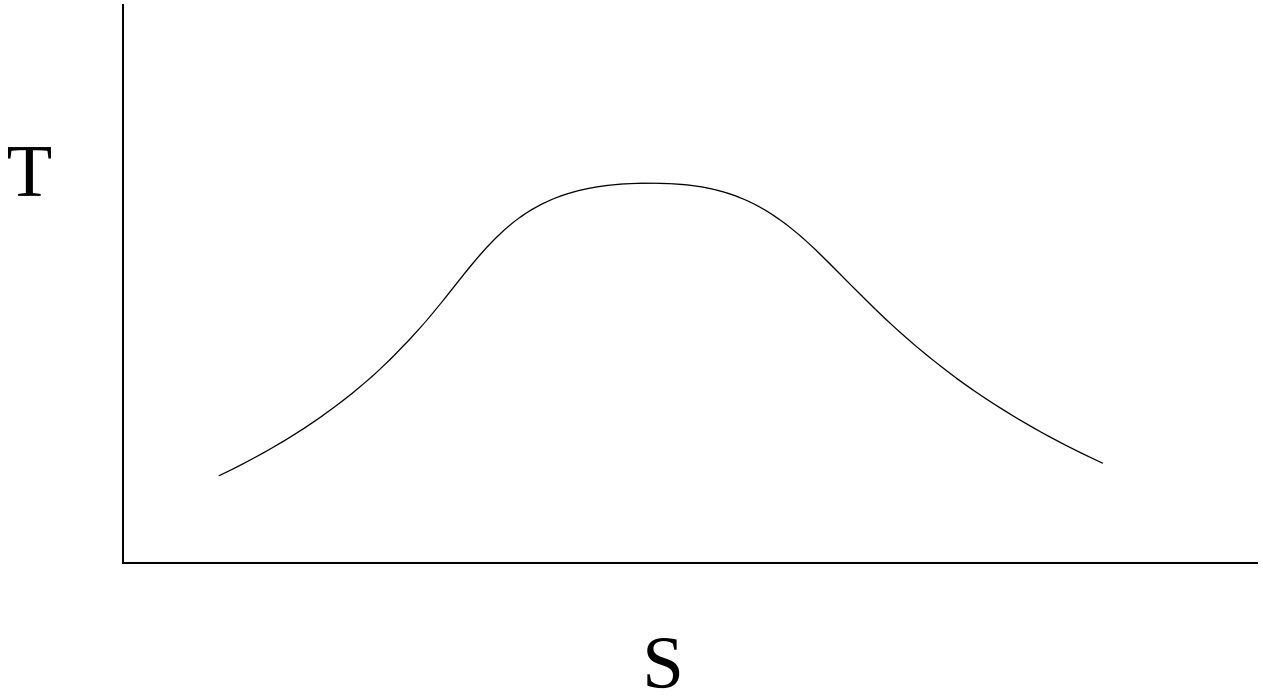
Example 4.4 OVC

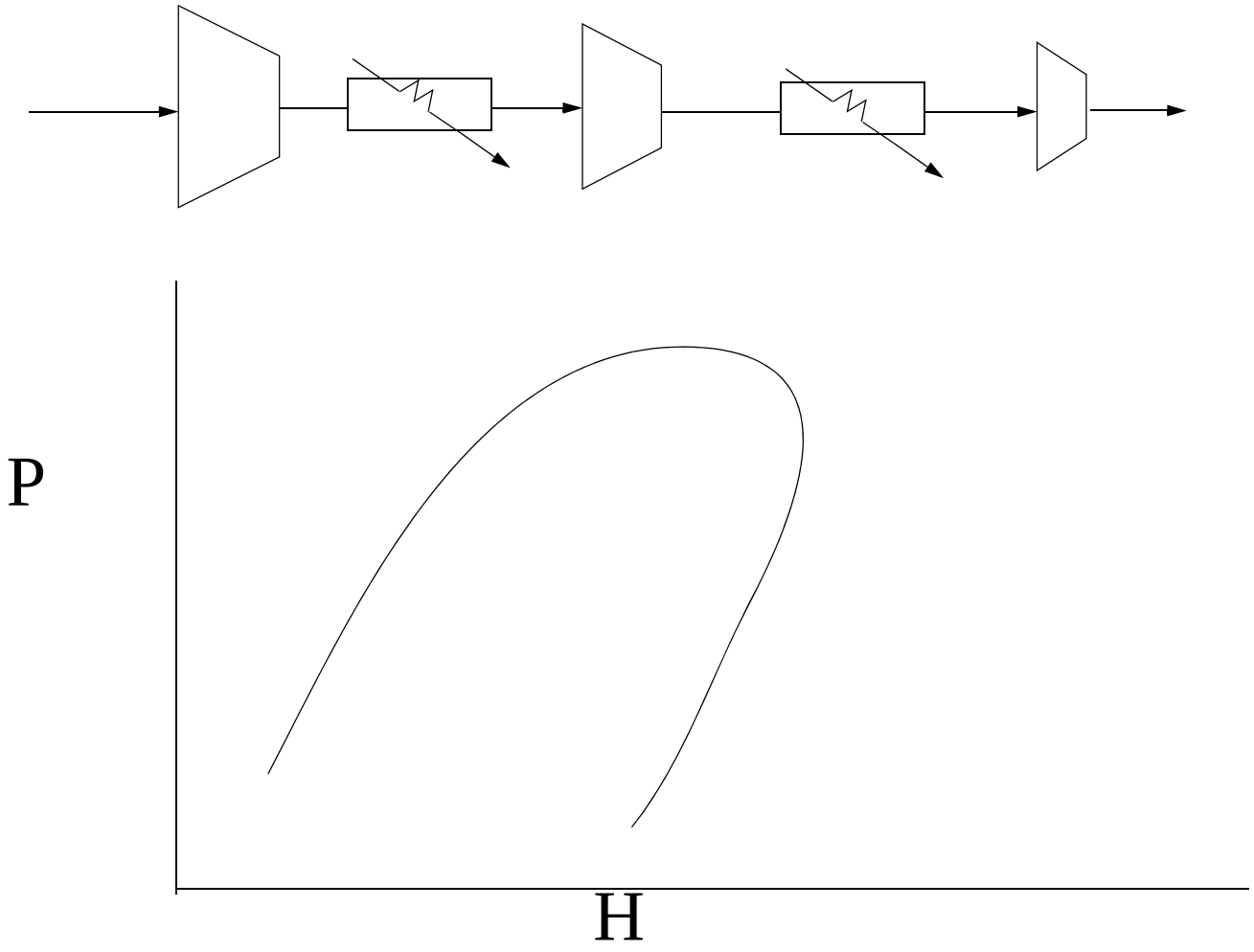
Example 4.6 Liquefaction



4.7 Multistage Compression






P
H