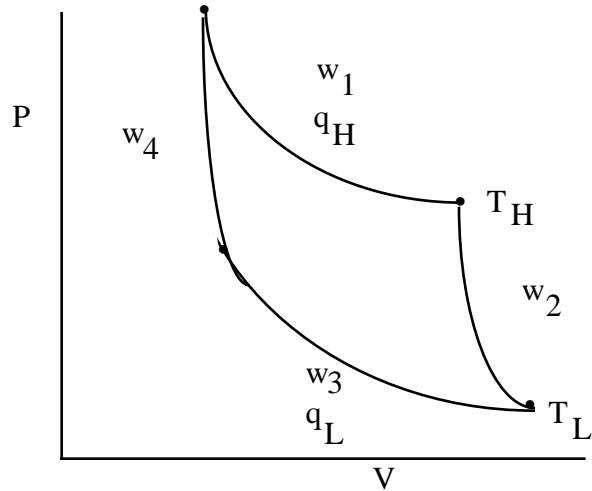
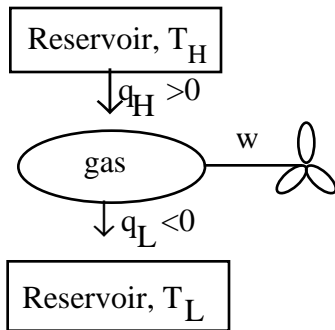


Efficiency of Cyclic Processes- Carnot Cycle



$$\Delta U = q + w$$

$$\Delta U = q_H + q_L + w_1 + w_2 + w_3 + w_4$$

$$w = w_1 + w_2 + w_3 + w_4$$

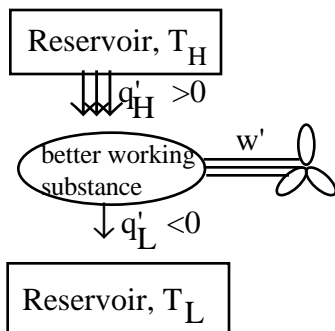
$$w = -(q_H + q_L)$$

$$\epsilon = \frac{-w}{q_H} = \frac{q_H + q_L}{q_H}$$

Comments:
for reversible or irreversible Carnot cycles

Does any reversible Carnot Cycle give the maximum amount of work?

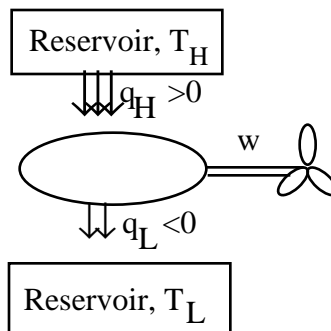
Assume that a more efficient cycle exists and look for an inconsistency:



more work
less wasted energy

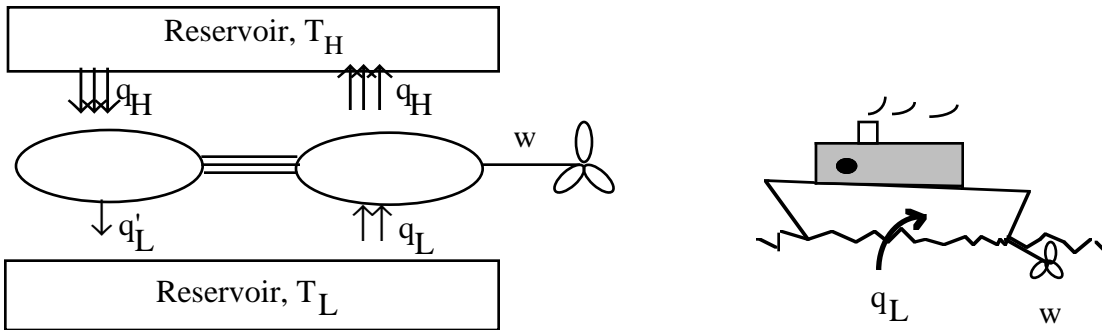
$$\epsilon' > \epsilon$$

$$q'_H = q_H$$



less work
more wasted energy

Now run the less efficient cycle as a heat pump and use the more efficient cycle to drive the heat pump.



The net result is that work is still available to do useful things. But where does the energy come from for this work? It can't come from the high temperature reservoir, because the same amount of energy is being drawn from the reservoir as is being pumped back in. The energy to pay for the work comes from the low temperature reservoir!! This is inconsistent with our experience. Such a situation is called perpetual motion of the second kind.

Our original assumption must then be incorrect. Therefore, any reversible Carnot cycle operating between the same two temperatures gives the same, maximal amount of work.

Principle of Thomson: It is impossible to devise an engine that working in a cycle shall produce no effect other than the extraction of heat from a reservoir and the performance of an equal amount of work.

Principle of Clausius: It is impossible to devise an engine that working in a cycle shall produce no effect other than the transfer of heat from a colder to a hotter body.