* Second law of Thermodynamics

or

Qualitative law / Direction law

or law of degradation of energy

FLOT simply says that total energy is conserve but it doesn't provide any information regarding the physibility of the possible energy converstion

It is the SLOT which provides the direction of possible energy conversation through the concept of entropy and due to this reason it is applied first in numerical to find out possible energy conversion direction then apply FLOT.

Note:- ① Heat is considered as low grade energy and work is a high grade energy

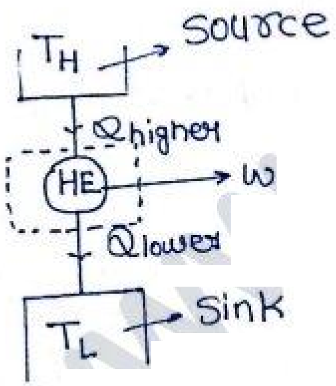
② Complate conversion of heat into work is not possible but the complate conversion of work in heat is possible

Thermal Energy Reservoir :-

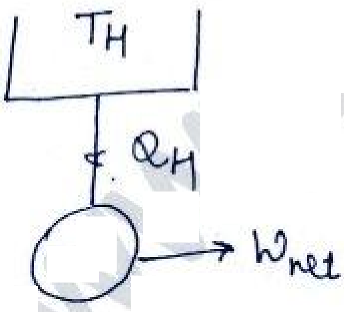
It is a reservoir infinite heat capacity

Source :- Supplier of heat energy without any changes in its temprature.

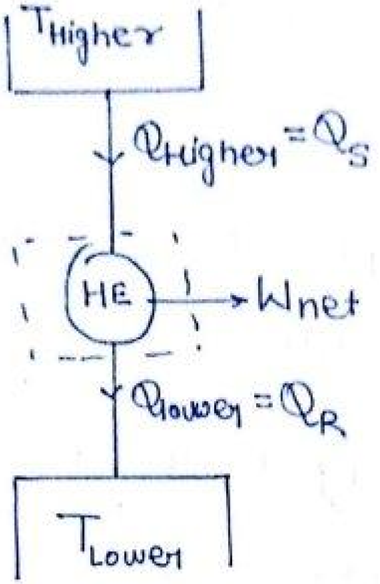
Sink :- Absorber of heat energy without any change in its temprature.



kelvin Planks :- It is impossible to construct a device which operate in a cycle produces work continuosly while interacting with single thermal reservoir



⇒ Such type of Device is impossible



efficiency

$$\eta = \frac{output}{Input}$$

$$\eta = \frac{W_{net}}{Q_S} = \frac{Q_{net}}{Q_S}$$

$$\eta = \frac{Q_S - Q_R}{Q_S} = 1 - \frac{Q_R}{Q_S}$$

$$\boxed{\eta = 1 - \frac{Q_L}{Q_H}}$$ Actual

Thermodynamics temp. scale or kelvin temp. scale

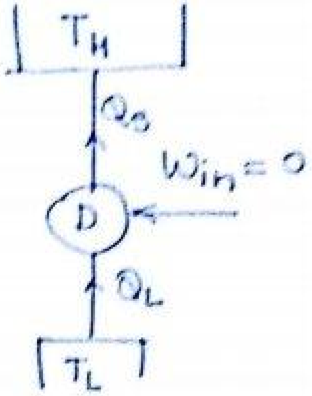
$$Q \propto T$$

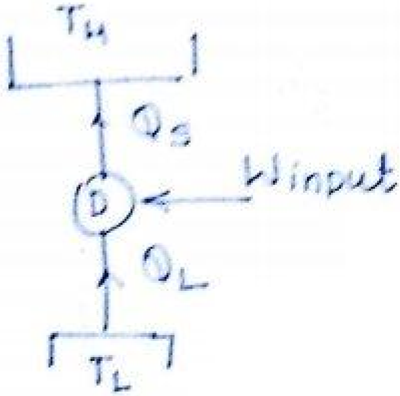
$$\frac{Q_L}{Q_H} = \frac{T_L}{T_H} \quad + \quad \boxed{\eta = 1 - \frac{T_L}{T_H}}$$ ideal

Imp ☆☆

Note:- kelvin plank's provides the concepts of work producing device i.e. Heat engine.

Clausiaus statement:- It is impossible to construct a device which transfer heat from low temp. reservoir to high temp. reservoir without consuming any form of energy





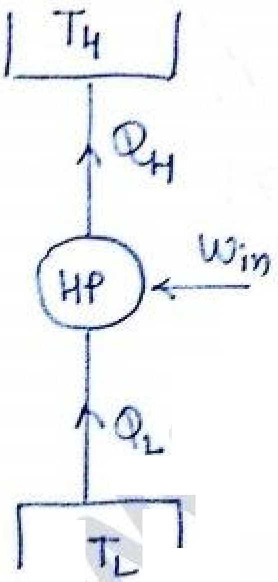
(Not possible)

Note:- Clasius statement provides the concept of work ~~to~~ absorbing device e.g. Heat pump and refrigerator.

COP:- Coefficient of performance/Energy

It is defined as the ratio of desired effect to the work input

Heat pump



$$(COP)_{HP} = \frac{\text{Desired effect}}{W_{in}}$$

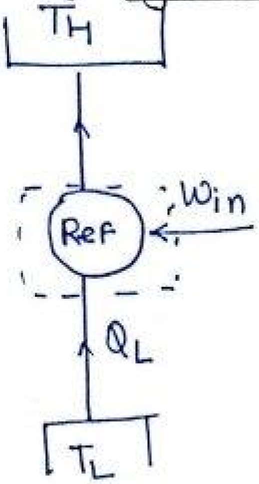
$$W_{in} + Q_L = Q_H$$

$$W_{in} = Q_H - Q_L$$

$$\boxed{(COP)_{HP} = \frac{Q_H}{Q_H - Q_L}}$$

$$\boxed{(COP)_{HP} = \frac{T_H}{T_H - T_L}}$$

Refrigeration



$$(COP)_{Ref} = \frac{DE}{W_{in}} = \frac{Q_L}{Q_H - Q_L} = \frac{T_L}{T_H - T_L}$$

$$\boxed{(COP)_R = \frac{T_L}{T_H - T_L}}$$

Relationship between $(COP)_{HP}$ & $(COP)_{Ref}$.

$$1 + (COP)_R = \frac{T_L}{T_H - T_L} + 1$$

$$= \frac{T_L + T_H - T_L}{T_H - T_L}$$

$$1 + (COP)_R = \frac{T_H}{T_H - T_L} = (COP)_{HP}$$

$$\boxed{(COP)_{HP} = 1 + (COP)_{Ref}}$$

The above expression is applicable between the same temp limit

Question The efficiency of a Reversible heat engine is 40%. then determine COP of Reversible H.P.

Sol^n

$$\eta = 1 - \frac{Q_L}{Q_H} = 0.40 \Rightarrow Q_L = 0.60\, Q_H$$

$$(COP)_{HP} = \frac{Q_H}{Q_H - Q_L} = \frac{Q_H}{Q_H - 0.60\, Q_H}$$

$$(COP)_{HP} = \frac{1}{0.40} = 2.5$$

$$(COP)_{HP} = \left(1 + (COP)_R\right) = \frac{1}{\eta_{HE}}$$

★ Above expression is applicable between same temp limits

Note:- Both heat pump and refrigerator are known as reversed heat engine.

Clausius Inequality :-

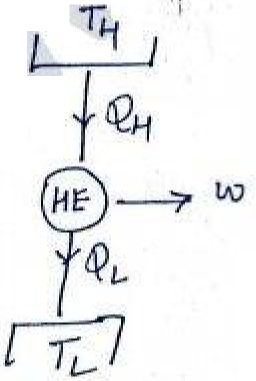
According to this the cyclic Integral for Factor $\frac{dQ}{T} \leq 0$

$$\oint \frac{dQ}{T} \leq 0$$

$\oint \frac{dQ}{T} < 0 \longrightarrow$ irreversible process

$\oint \frac{dQ}{T} = 0 \longrightarrow$ Reversible process

$\oint \frac{dQ}{T} > 0 \longrightarrow$ Impossible



$$\frac{Q_H}{T_H} - \frac{Q_L}{T_L} \begin{matrix} < 0 \\ = 0 \\ > 0 \end{matrix}$$