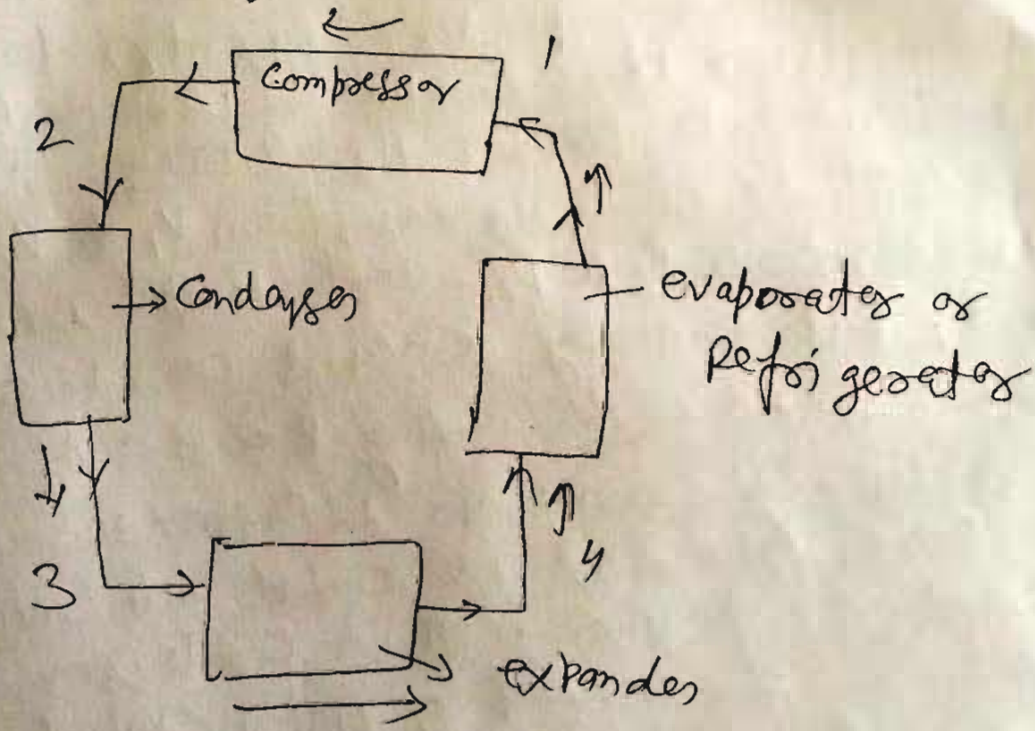
B. Tech - Ag - 2nd Sem, Lecture - 7 - Sub: Thermodynamics, Refrigeration and Air Conditioning — by - Yogesh Kumar

Topic - Bell - Coleman or Reversed Joule Brayton cycle

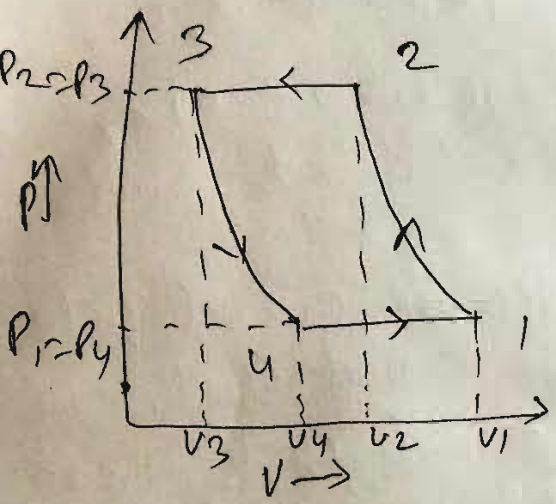
The Bell Coleman cycle is a ~~cycle~~ Refrigeration cycle, where the working fluid or Refrigerant is air, which is compressed and expanded but do not change its ~~state~~.

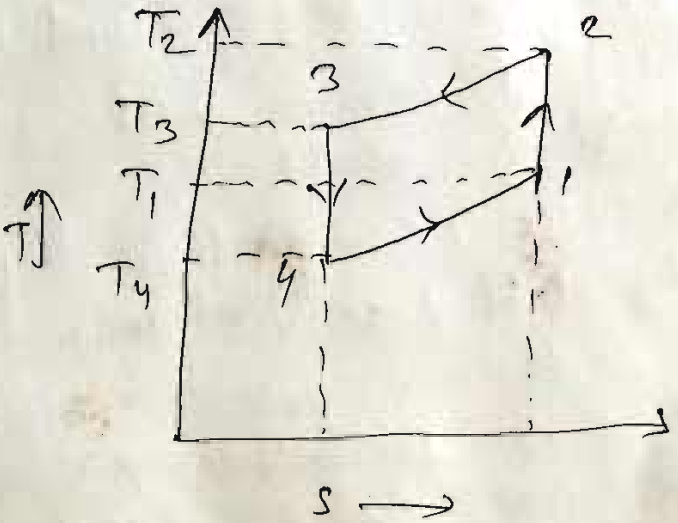
This cycle is a modification of Reverse Carnot cycle, only difference between reverse Carnot cycle and Bell Coleman cycle is that in Carnot cycle there are two ~~isentropic process~~ isothermal process which are replaced by two isobaric processes in the Bell-Coleman cycle -



The above fig. shows the different processes in a Bell-Coleman cycle. This cycle consists of a compressor, a cooler or Condenser, an expander or throttling device and a evapo~~rator~~ or Refrigerator.

In this cycle, the process of compression and expansion of gas (Air) is isentropic and heat absorption and rejection of heat takes place at constant pressure or isobaric process.





Process-(1-2)-Isentropic Compression- In this process air is drawn from evaporator (refrigerator) to compressor cylinder where it is compressed isentropically. No heat interactions takes place in this process. As the air is compressed, the volume decreases from V_1 to V_2, pressure increases from P_1 to P_2 and Temp^{r} increase to T_1 to T_2 but entropy remains constant.

Process-(2-3)- Adiabatic cooling process → After isentropic compression, the warm air is passed through condenser or cooler, where it is cooled adiabatically at constant pressure. This condenser or cooler can be an air cooled or water cooled cooler. In this cooling process, pressure will remain constant but Temp^{r} will decreases, volume will decrease and entropy will also decreases.

Bell Coleman cycle - Contnd -

Process (3-4) - Isentropic Expansion → In this process, the cooled & condensed Air is expanded isentropically. Since Air is expanded, therefore volume will increases and pressure will decreases. As this process is isentropic therefore entropy will remain constant and Temp^{r} will decrease.

Process (4-1) - Adiabatic Refrigeration → In this process (last process) the condensed and expanded air absorbs heat from the evaporator & Refrigerator. Heat is Transfered from evaporator to air. In this process, the air expands due to heat from volume V_4 to V_1, the temp^{r} increases from T_4 to T_1 and entropy will also increase from S_4 to S_1.

Now - Heat absorbed by air, $Q_{in} = C_p(T_1 - T_4)$

and Heat rejected by air $Q_{out} = C_p(T_2 - T_3)$

Work done of Bell-Coleman cycle -

Work done during the cycle per kg of air

W = Heat Rejected - Heat absorbed

$= Q_{out} - Q_{in}$

$= C_p(T_2 - T_3) - C_p(T_1 - T_4)$

Therefore C.O.P [Coefficient of Performance] of Bell-Coleman cycle -

$$(C.O.P) = \frac{Q_{in}}{Q_{out} - Q_{in}} = \frac{C_p(T_1 - T_4)}{C_p(T_2 - T_3) - C_p(T_1 - T_4)}$$

$$\boxed{(C.O.P) = \frac{T_1 - T_4}{(T_2 - T_3) - (T_1 - T_4)}}$$