to Bi at the junction A and from Bi to Sb at the junction B (fig. 2.). When the ~~jun~~ direction of the current is reversed, the heat is evolved at the junction B and absorbed at A. This shows that Peltier effect is reversible.

The amount of heat absorbed or evolved at the junction when unit current flows for one second is called the Peltier co-efficient.

If H Joule be the amount of heat energy absorbed or evolved at the junction ~~when unit current flows for one second~~ by passage of q Coulomb of charge, then

$$\text{Peltier Co-efficient, } \pi = \frac{H}{q}$$

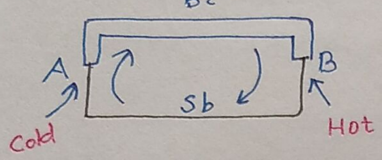
The unit of π is volt.

Next, we draw an arrangement (fig. 3.) ~~to~~ for the experimental demonstration of Peltier effect.

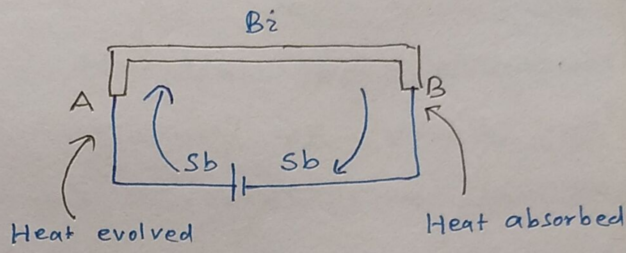
The arrangement shown by fig. 3. is known as S. G. Starling

Ques :- What is Peltier effect ? Define Peltier Coefficient. Describe an experiment to demonstrate Peltier effect.

If a current is sent round the circuit of a thermocouple, heat is evolved at one junction and absorbed at the other i.e., one junction is heated and the other is cooled. This is Peltier effect.



(fig. 1.)



(fig. 2.)

In an (Sb - Bi) couble when the junction B is heated, and A is kept cold, current flows from Sb to Bi at the junction A and from Bi to Sb at the junction B as shown in fig. 1. When a battery is placed in the circuit and both junctions A and B are kept at the same temperature, heat is evolved at the junction A and absorbed at the junction B provided the current flows from Sb

$$t_2' = \gamma \left[t_2 - \frac{vx}{c^2} \right] \quad \text{———— (3)}$$

Subtracting (2) from (3), we get

$$t_2' - t_1' = \gamma (t_2 - t_1)$$

or, $$\Delta t' = \gamma . \Delta t$$

Δt = time interval in system s'.

or $$\Delta t' = \frac{\Delta t}{\sqrt{1 - \frac{v^2}{c^2}}} \quad \text{———— (4)}$$

Clearly, $\Delta t' > \Delta t$.

Thus the time interval Δt appears to the moving observer to be lengthened or dilated, i.e. a moving clock always appears to go slow. The clock will run more. and more slowly if the relative Velocity between the clock and observer increases more and more. This is app- -arent retardation of clocks.

— × —

velocity v in the direction of motion. This is Lorentz-Fitzgerald contraction.

Thus according to Lorentz-Fitzgerald contraction every rigid body has maximum dimensions when at rest and its dimensions appear to be contracted in the direction of motion by a factor $\sqrt{1-\frac{v^2}{c^2}}$, v = velocity of the body.

Time dilation or Apparent retardation of clocks:

Let there be two systems S and S' the latter moving with velocity v relative to S along +X-axis.

Let a clock be situated in systems at any point x and give signals at t_1 and t_2, then the interval Δt in S is given by

$$\Delta t = t_2 - t_1 \qquad \text{———— (1)}$$

If t_1' and t_2' be the corresponding times in system S', then according to Lorentz transformations, we have

$$t_1' = \gamma\left[t_1 - \frac{vx}{c^2}\right] \qquad \text{———— (2)}$$

(4)

Lagrange Equation of motion:

A system is characterised by a function L which is a function of generalised co-ordinate, generalished velocities and time i.e.

$$L \equiv L(q, \dot{q}, t)$$

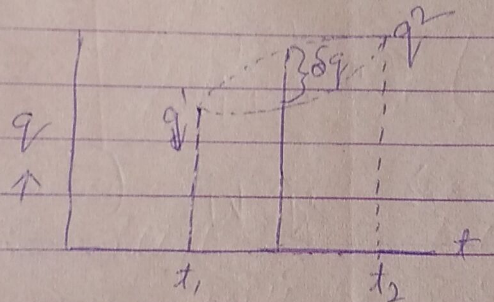
Where $q \equiv q_1, q_2, q_3 \ldots\ldots q_s$

$\dot{q} \equiv \dot{q}_1, \dot{q}_2, \dot{q}_3 \ldots\ldots \dot{q}_s$

Let the system move from time t_1 to time t_2 and occupy two positions q^1 and q^2 respectively, then

$$S = \int_{t_1}^{t_2} L(q, \dot{q}, t)\, dt \quad \ldots\ldots (1)$$

where L is known as the Lagrangian of the system and S is called action.



There may be a number of paths through which system can move from initial point to final point. We chose the path such that S taken the least possible value.

The necessary condition from S to have a minimum is that the variation of S is zero.

Thus

$$\delta S = \delta \int_{t_1}^{t_2} L(q, \dot{q}, t)\, dt = 0 \quad \text{---} (2)$$

Substituting (3) in (2) we get

$$\vec{P} = \sum_{i=1}^{N} m_i \sum_{j=1}^{n} \frac{d\vec{r_i}}{dq_j} \dot{q_j}$$

$$= \sum_{j=1}^{n} \left(\sum_{i=1}^{N} m_i \frac{d\vec{r_i}}{dq_j} \right) \dot{q_j}$$

$$= \sum_{j=1}^{n} \sum_{i=1}^{N} a_{ij} \dot{q_j}$$

$$= \sum_{j=1}^{n} p_j \quad \text{---} (4)$$

Where we have defined

$$a_{ij} = m_i \frac{d\vec{r_i}}{dq_j}$$

and $p_j = \sum a_{ij} \dot{q_j} \quad (j = 1, 2, \ldots n)$ ---- (5)

Here $p_1, p_2 \ldots p_n$ are known as generalised momenta.

—— x ——

Contribution of electronic angular momentum Let us consider the simplest case of intert gases in their ground state. The ground state is not degenerate and the electronic partition function is

$$Q_e = e^{-\epsilon_0/kT}$$

For monatomic gas, we put $\epsilon_0 = 0$, so that $Q_e = 1$ and hence $A_e = 0$. So it will not contribute to the specific heat.

Contribution of nuclear spin → Let us now consider the effect of nuclear spin i, which causes hyperfines splitting of atomic levels. The corresponding energy is $(2i+1)$. Thus nuclear spin partition function is,

$$Q_n = (2i+1).$$

Then

$$A_n = -NkT \log(2i+1)$$

and

$$u_n = 0$$

and it does not effect the specific heat.

——— x ———

Rough
$N(\log N - 1)$
$= N(\log N - \log e)$
$= N \log (N/e)$.

We can write,

$$A = -NkT \log \left[\frac{eV}{N} \left(\frac{2\pi m k T}{h^2} \right)^{3/2} Q_e Q_n \right].$$

$$= A_{tr} + A_e + A_n \quad \text{——} \quad (9)$$

where,

$$A_{tr} = -NkT \log \left[\frac{eV}{N} \left(\frac{2\pi m k T}{h^2} \right)^{3/2} \right] \quad \text{——} \quad (10)$$

$$A_e = -NkT \log Q_e \quad \text{——} \quad (11)$$

$$A_n = -NkT \log Q_n \quad \text{——} \quad (12)$$

A_{tr}, A_e and A_n are the contributions to the free energy due to the translation motion, electronic ~~angla~~ ~~ge~~ angular momentum and nuclear spin respectively.

<u>Contribution of translational motion</u> —

(10) can be written as

$$A_{tr} = -NkT \log \left(\frac{eV}{N} \right) - \tfrac{3}{2} NkT \log (kT)$$

$$- \tfrac{3}{2} NkT \log \left(\frac{2\pi m}{h^2} \right) \quad \text{—} \quad (13)$$

The entropy is,

$$S_{tr} = -\left(\frac{\partial A_{tr}}{\partial T} \right) = + Nk \log \left(\frac{eV}{N} \right) + \tfrac{3}{2} Nk \log (kT)$$

$$+ \tfrac{3}{2} Nk + \tfrac{3}{2} Nk \log \left(\frac{2\pi m}{h^2} \right) \quad \text{—} \quad (14)$$

The internal energy

$$U_{tr} = A_{tr} + S_{tr} T = \tfrac{3}{2} NkT \quad \text{——} \quad (15).$$

and the specific heat at constant volume

$$(C_V)_{tr} = \left(\frac{\partial U_{tr}}{\partial T} \right)_V = \tfrac{3}{2} Nk \quad \text{——} \quad (16)$$

which is independen of T.

in this system at the same time t, then we have

$$x_2 - x_1 = l \qquad \text{——— (2)}$$

l = length of the rod in motion.

According to Lorentz transformations,

$$x_1' = \gamma (x_1 - v t) \qquad \text{——— (3)}$$

$$x_2' = \gamma (x_2 - v t) \qquad \text{——— (4)}$$

Subtracting (3) from (4) we get,

$$x_2' - x_1' = \gamma (x_2 - x_1)$$

or, $l_0 = \gamma \, l$

or, $l = \dfrac{l_0}{\gamma}$

~~or, l =~~

$$\therefore \; l = l_0 \sqrt{1 - \frac{v^2}{c^2}} \qquad \text{——— (5)}$$

$$\because \; \gamma = \sqrt{1 - \frac{v^2}{c^2}}$$

Clearly, $l < l_0$

From (5) we see that the length of the rod is contracted in the ratio $1 : \sqrt{1 - \frac{v^2}{c^2}}$, when moving with

Q → What are the consequences of Lorentz transformation equation ? Explain.

or

What do you understand by Lorentz - Fitzgerald contraction and Time dilation? Explain.

There are two consequences of Lorentz transformation equation:

(1) Lorentz - Fitzgerald contraction

and

(2) Time dilation or Apparent retardation of clocks.

we shall explain the two one by one.

Lorentz - Fitzgerald contraction :- Let there be a rod parallel to x-axis placed in system S' at rest. If x_1' and x_2' are the abscssae of the ends of the rod in S' at the same time t', we have

$$x_2' - x_1' = l_0 \qquad (1)$$

l_0 = length of the rod at rest.

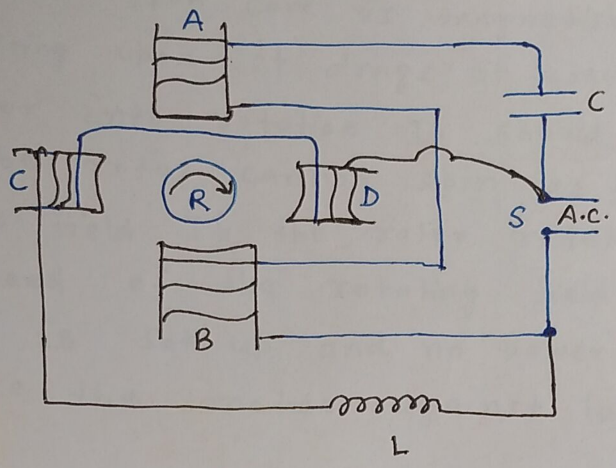
If l is the length of the rod in system S, x_1 and x_2 the absci-assae of the ends of the rod is produced.

When the rotor is placed in the rotating magnetic field, the rings and the conductors act like a loop of wire and induced current is set up. Due to this large induced current the iron core is magnetised and the field acting upon it drags it around and sets the rotor into rotation. It should be noted that the rotor cannot spin as fast as the magnetic field. If the rotor rotates with the speed of the rotating field, no induced current is set up and no power is available to drive the motor against load.

— * —

Ques:- Explain Induction Motor.

A clean diagram for an Induction Motor is shown below.



(fig.)

The rotor R of an induction motor consists of an iron core, like the core of a drum armature, with large copper bars placed in slots along the circumference. These bars are connected to heavy copper rings at the ends. This is known as squirrel cage rotor. The stator consists of two pairs of coils AB and CD connected to A.C. supply through a capacitance or an inductance as shown in the fig. above. The current in the two pairs of coils differs in phase by $\pi/2$ and a rotating magnetic field