8.23 Determination of Stefan's Constant (Laboratory Method)

The laboratory apparatus used to determine the Stefan's constant is shown in Fig. 8.12. A hollow hemispherical metallic vessel *A* is enclosed in a wooden box *W*. The inner surface of *A* is coated with

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...black and the wooden box W is lined with tin plates. ...whole apparatus is placed on a wooden base having a ...hole at its centre. The vessel A is heated by passing ...inside the box and A acts as a black body radiator. ...thermometers $T\,T$ record the temperature of A.

A small silver disc B whose upper surface is coated ...lamp black is placed at the central hole. The ebonite ...ring C is used to cover and uncover the disc B from ...radiations of the enclosure. It can be arranged from ...side with the help of the handle H. The disc B is ...nected to a thermocouple arrangement. One junction ...the thermocouple is immersed in a tube containing oil. ...tube is surrounded by a beaker containing water. A ...sitive galvanometer G is used in the circuit. The leads ...nected to the terminals of the galvanometer are ...mersed in cotton wool in the box F to avoid any ...rbation effect due to the difference of temperature in the leads. A rheostat Rh can be used in the ...cuit to obtain the deflection within the range. The actual experiment consists of two parts.

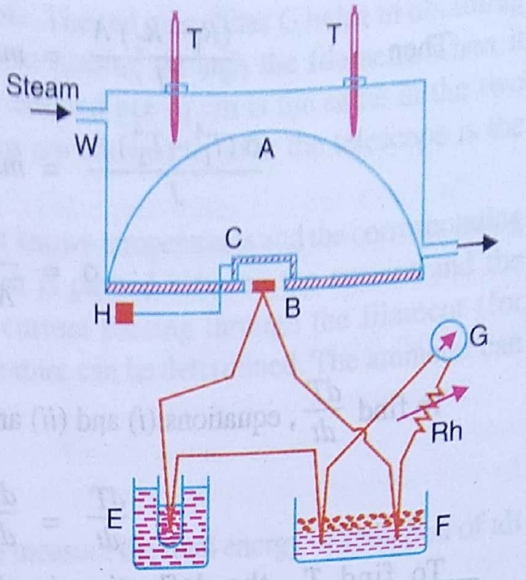

Fig. 8.12

1. The thermocouple is first standardized. Before ...sing steam into the chamber, the disc B is at the room ...perature. The water bath E acts as a hot junction. It is ...ated and at various temperatures of the hot junction, the ...esponding deflections in the galvanometer are noted. A ...ph between the difference of temperature of the hot junction ...the room temperature along the Y-axis and galvanometer ...ection along X-axis is plotted (Fig. 8.13). From the graph,

$$\frac{dT}{d\theta} = \tan\alpha = \frac{AB}{BC} \qquad ...(i)$$

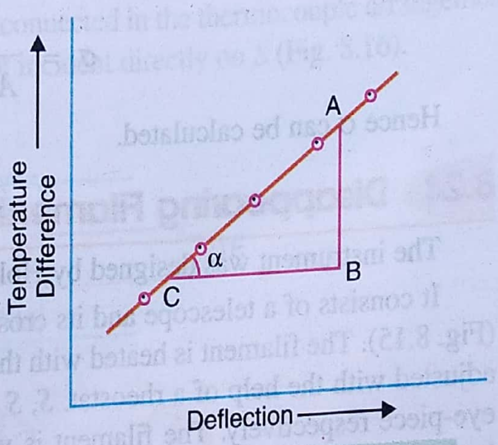

Fig. 8.13

2. The disc is completely covered with C and steam ...passed into the chamber. After some time, the ...rmometers $T\,T$ show constant temperature. The bath E is ...at room temperature. With the help of the handle H, the cover C is tilted so that the upper surface ...the disc B receives the radiations from the enclosure. The deflections in the galvanometer are ...erved after equal intervals of time (say 10 seconds). A graph is plotted between time and deflection ...g 8.14). A tangent is drawn on the curve at a point D.

$$\frac{dt}{d\theta} = \tan\beta = \frac{EF}{GF} \qquad ...(ii)$$

...eory

Let, at any instant, the temperature of the enclosure and the disc be T_1 and T_2 (degrees Kelvin) ...pectively. The disc will absorb more heat from the surroundings and radiate less heat to the ...roundings. Its temperature will rise. From Stefan's law,

$$R_1 = \sigma T_1^{\,4} \text{ and } R_2 = \sigma T_2^{\,4} \qquad ...(iii)$$

$$\therefore \quad (R_1 - R_2) = \sigma (T_1^{\,4} - T_3^{\,4})$$

Here, R_1 is the amount of heat radiation absorbed per unit area per second by the disc and R_2 is ...amount of heat radiation emitted per unit area per second by the disc.

Let the mass of the disc be m, specific heat S, rate of rise of temperature dT/dt, and area of the ...per surface A.

$$\text{Then} \qquad \frac{(R_1 - R_2)\, A}{J} = mS \frac{dT}{dt}$$

$$\frac{\sigma\,(T_1^4 - T_2^4)\, A}{J} = mS \frac{dT}{dt}$$

$$\sigma = \frac{JmS}{A\,(T_1^4 - T_2^4)} \times \frac{dT}{dt} \qquad ...(iv)$$

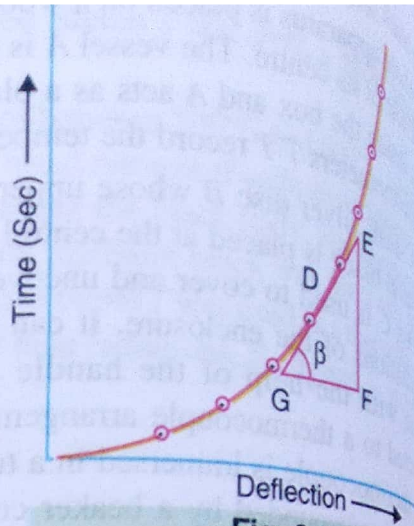

Fig. 8.14

To find $\frac{dT}{dt}$, equations (*i*) and (*ii*) are used.

$$\frac{dT}{dt} = \frac{dT}{d\theta} \times \frac{d\theta}{dt} = \frac{\tan \alpha}{\tan \beta}$$

To find T_2, the deflection in the galvanometer corresponding to the point *D* on graph in Fig. 8.14 is noted and for this deflection, the tempe difference from the graph (Fig. 8.13) is noted. To this reading add the room temperature and fi in degrees Kelvin.

Substituting these values in equation (*iv*)

$$\sigma = \frac{JmS \tan \alpha}{A\,(T_1^4 - T_2^4) \tan \beta}$$

Hence σ can be calculated.

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