DETERMINATION OF "J" by CALLENDAR AND BARNE'S MATHOD

OBJECT: To determine J (Mechanical equivalent of heat) by Callendar and Barne's method (continuous flow calorimeter).

FEATURES:

The set up consists of the following:

1. Callendar and Barne's apparatus OMEGA TYPE CFB-196.
2. Constant level bath with stand.
3. Battery Eliminator, 2-12v D.C. in steps/variable at 4A IC regulated and short circuit protected OMEGA TYPE BE-12/4.
4. D.C. Ammeter, 65mm round dial, mounted on Bakelite stand, to read 0-3A OMEGA TYPE MO-65.
5. D.C. Voltmeter, 65mm round dial, mounted on Bakelite stand, to read 0-15VOMEGA TYPE MO-65.
6. Adequate no. of connecting wires, 100cm long

OTHER APPARATUS REQUIRED

1. Digital Stop Clock OMEGA TYPE DSC-602 with START/STOP operation by means of toggle switgh & RESET by a push button switch. It has a range of 999.9 seconds with resolution of 0.1 seconds and accuracy of ±0.01% (Quartz controlled). Display is thorough 4 no's of 12.5mm bright seven segment Display's and working voltage of the unit is 230V± 10% 50 Hz.
2. Physical balance with weight box.
3. Two thermometers 100°C x1/10°.
4. Beaker, rubber tubing etc.

DESCRIPTION OF APPARATUS

Callendar and Barn's apparatus consists of Nichrome resistance wire in the form of the coil placed centrally along the axis of a narrow glass tube. This wire serves as heater as well as stirrer. The ends of wire are connected to metal tubes provided at the ends of glass tube. Continuous flow of water is maintained (using

a constant level bath) through the tube and the temperatures of inlet and outlet are measured by two thermometers T1and T2. The resistance coil is connected in series with the Battery Eliminator OMEGA TYPE BE-12/4 and the ammeter 0-3AD.C. OMEGATYPE MO-65.A voltmeter 0-15V D.C.OMEGATYPE MO-65 is connected across the terminals of resistance wire. The whole arrangement is shown in Fig.1.

THEORY

Let E1 be the p.d in volts across resistance wire in which I1 ampere current is flowing. The amount of work W per sec. is given by:

$$W = E_1 I_1 \times 10^7 \text{ ergs}$$

If corresponding heat produced is H, it is used to heat the resistance wire etc. initially. But after temperature of inlet & outlet become constant this will be used in heating the water which is flowing constantly in the tube. A small portion of heat will be radiated. Now if m1 be mass of water flowing per second through the tube and $\theta 1$ and $\theta 2$are inlet and outlet temperatures respectively, we have

Heat taken by water per sec = $m_1 (\theta 2 - \theta 1)$

The specific heat of water may be taken to be unity . Also if radiated amount of heat be R1, we have

Total amount of heat produced, $H = m_1 (\theta 2 - \theta 1) + R$ ……(2)

Using equation (1) & (2) $m_1 (\theta 2 - \theta 1) + R = \frac{E1I1}{J} \times 10^7$ ……..(3)

Now again the current through wire and flow of water such that the temperatures $\theta 1$ and $\theta 2$ remain unaltered. If current and p.d. $I_2$and E_2

respectively and corresponding to this m2 be mass of water flowing per second we have:

$$M2\ (\theta 2 - \theta 1) + R = \frac{E2I2}{J} X10^7$$

……(4)

Hence from (3)and (4) by subtracting

$$(m_1\text{-}m_2)\ (\theta_2 - \theta_1) = \left(\frac{E1I1-E2I2}{J}\right) X\ 10^7$$

$$J = \frac{(E1I1-E2I2)}{(M1-M2)(\theta 2-\theta 1)} X10^7 \quad ergs/cal$$

…….(5)

OBJECT

To determine J (Mechanical equivalent of heat) by Callendar and Barne's method (continuous flow calorimeter) .

PROCEDURE

1. Make clean and tight connections shown in fig. 1. Insert thermometer T1 and T2.

SR.NO.	P.D (Volts)	Mean P.D(Volts) E	Current (Amp.)	Mean (Amp.)	Mass of Beaker + (grams)	Mass of water (grams)	Time (sec.)	Mean Rate of mass of water Flowing out

FIG. 1. TO DETERMINE ' J ' BY CALLENDAR AND BARNE'S MATHOD.

2. Connect constant level bath at one end of Callender and Barne's calorimeter and adjust flow of water.
3. Connect Battery Eliminator to main socket carrying 230V ± 10% at 50Hz AC. Now switch on the battery Eliminator. The flow of water and strength of current by using pot. Of Battery Eliminator should be so adjusted that a difference of temperature of about 5^0C between inlet and outlet is obtained.
4. Not the values of E_1 and I_1.
5. When the temperatures as shown by the thermometer remain steady for about 10 to 15 minutes, note the temperatures.
6. Collect flowing water for a known time by using Digital Stop Clock OMEGA TYPE DSC-602 in a weighted beaker and find rate of flow of water.
7. Now alter the value of p.d & current and adjust again flow of water such that temperatures as shown by thermometers remain unaltered.
8. Not readings for E_2, I_2 and m_2 as in previous set.
9. Finally switch off current and there after cut off water supply.
10. Calculate " J " from the relation (5).

OBSERVATION

Temperature of water : inlet θ_1 = …….. Outlet θ_2 = ……..^{0}C,

Mass of empty beaker ……..gms

1.								m_1 = ……
2.								M_2 = ……

NOT E: Take more sets if possible.

CALCULATIONS:

$$J=\frac{(E_{1I_1}-E_{2I_2})}{(m_{1-m_2})(\theta_{2-\theta_1})}X10^7 =\text{.....ergs/cal.}$$

RESULT Mechanical equivalent of heat ' J ' = ...ergs / cal.

Standard value 4.18 x 10^7 ergs / cal. Percentage error ……

PRECAUTIONS

1. The connections must be tight. See that voltmeter and ammeter are connected properly.
2. The flow of water and current should be properly adjusted at both times so that the temperatures θ_1& θ_2 may remain unaltered.
3. The difference of temperatures (θ_2 - θ_1) should be of the order of 5 to 7^0 C .
4. The thermometers used for temperature measurement must be capable of reading of temperatures up to one – tenth of a degree.
5. Current in the wire should only be started when water is flowing and before cutting off the water supply it should be switched the resistance wire will burn.

QUESTIONS

1. Explain " J " ?
2. Why it is denoted by letter " J" ?
3. How work is done here in this Experiment ?
4. Name other method for determination of " J "?
5. Which of the method you consider to be best ?Why?
6. What is the superiority of this method over others?
7. What are the chief sources of error in this method??

8. What are the precautions you use in performimg this experiment?
9. Why wire of particular shape is chosen?
10. How radiation loss is eliminated?
11. Can you use mercury instead of water? 3