(c) **Determination of ballistic constant**

If H is given, k can be calculated from formula (2)

$$k = \frac{2nAH}{r \times 10^9} \cdot \frac{1}{\theta_H \,(1+\lambda/2)} \text{ e.m.u.}$$

Precautions

(*i*) The galvanometer should be properly set so that the coil oscillates freely.

(*ii*) The galvanometer should be at a considerable distance from the earth inductor and the connections between the two should be made by twin flexible wires.

(*iii*) The earth inductor must be properly placed as stated in the procedure to determine θ_V and θ_H .

(*iv*) The time of rotation of the earth inductor should be small compared to the time period of the ballistic galvanometer

QUESTIONS

(*i*) Questions (*ii*) to (*iii*) same as in Expt No. 55.

(*ii*) Upon what factors does the e. m. f. induced in the coil depend when it is rotated in the magnetic field ?

(*iii*) Why should the coil be rotated quickly ?

(*iv*) Define magnetic elements at a place. Can you determine dip approximately with the help of two compass needles ?

(*v*) In what way is this method superior to other methods ?

(*vi*) What is the principle of a dynamo ?

Exp. 60. Self-inductance of a coil by Anderson's bridge

Objects

To determine the self-inductance of a coil by Anderson's bridge.

Apparatus

Post office box, condenser, A.C. source of suitable frequency *e.g.*, a buzzer or an A.F. generator, Leclanche cell and the experimental coil whose self-inductance is to be determined.

Theory

Anderson's bridge is a modified Wheatstone's bridge in which a condenser C with a variable resistance r in series is joined in parallel to an arm, say AD as shown in fig. 60.1. The experimental coil is put in the gap X meant for the unknown resistance.

In this arrangement, at first the rssistances P, Q, and R are adjusted with the steady current so that the potential at D or E is equal to that at H and no current passes through the galvanometer. Secondly, the variable resistance r is adjusted so that any instantaneous potential at E is equal to that at H and no current passes through the head-phone.

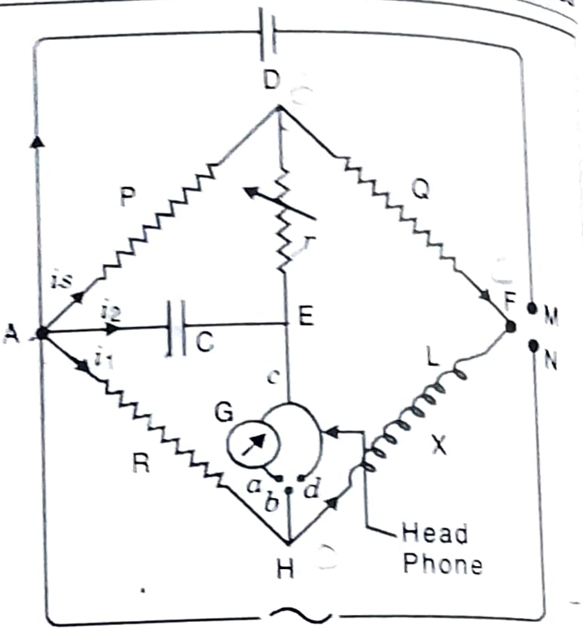

Fig. 60.1

(a) Suppose that the bridge has already been balanced for steady current i.e., the condition

$$\frac{P}{Q} = \frac{R}{X}$$

or $$\frac{P}{R} = \frac{Q}{X} = \frac{P+Q}{R+X} \quad ...(1)$$

has been established where X is the resistance of the coil.

(b) For alternating e.m.f. and current, the distribution of current has been shown in fig. 60.1. Let i_1, i_2 and i_3 be the instantaneous currents along AH, AE and AD respectively.

In the cucuit $AHFB$, applying Kirchoff's law,

$$i_1 (R+X)+L\frac{di_1}{dt} = e \quad ...(2)$$

where L is the inductance of the coil and e, the e.m.f. of A.C. source.

Time constant in this inductance circuit is given by

$$\lambda_1 = \frac{\text{coefficient of } \frac{di}{dt}}{\text{coefficient of } i} = \frac{L}{R+X} \quad ...(3)$$

In the circuit $ADFB$,

$$i_3P + Q(i_2 + i_3) = e \quad \text{or} \quad i_3 (P + Q) + i_2Q = e. \quad ...(4)$$

In the circuit ADE,

$$i_3P - i_2r - q/C = 0$$

where q is the charge flowing through the condenser and C, its capacity.

or $$i_3 = \frac{i_2r + q/C}{P} \quad ...(5)$$

From (4) and (5),

$$\frac{P+Q}{P}\left(\frac{q}{C}+i_2r\right)+i_2Q = e$$

or, $$\frac{P+Q}{PC}q+i_2\left(r\frac{P+Q}{PC}+Q\right)=e$$

On differentiating, we get,

$$\frac{P+Q}{PC}\cdot\frac{dq}{dt}+\frac{di_2}{dt}\left(r\frac{P+Q}{P}+Q\right)=0$$

or $$\frac{R+X}{RC}i_2+\frac{di_2}{dt}\left(r\frac{R+X}{R}+Q\right)=0. \qquad \left[\because i_2=\frac{dq}{dt}\right]$$

Time constant λ_2 of the capacity resistance circuit is given by

$$\lambda_2=\frac{\text{coefficient of } di/dt}{\text{coefficient of } i}=\frac{[r(R+X)/R]+Q}{(R+X)/RC}$$

With the steady current, the potentials of D and H or of E and H were adjusted to be the same. *The potentials at E and H will still remain the same while using the A.C. current if the rates of rise* or *fall of potential at E and H due to varying currents* i_2 *and* i_1 *are equal i.e., if the time constants of the inductance and the capacity-resistance circuits remain the same.* The bridge will, therefore, be balanced if

$$\lambda_1=\lambda_2$$

or $$\frac{L}{R+X}=\frac{[r(R+X)/R]+Q}{(R+X)/RC}=\left[\frac{r(R+X)+RQ}{(R+X)}\right].C$$

$\therefore$ $$L=C\ [(R+X)r+RQ]. \qquad \text{...from (1)}$$

Procedure

(*i*) Connections are made as shown in the figure through two double-way keys *abd* and *FMN*.

(*ii*) At first the battery circuit is alone completed with steady current. The capacity of the condenser and the inductance of the coil will not play any part. The resistances *P*, *Q* and *R* are adjusted so that galvanometer reads no deflection. In this way, the resistance of the experimental coil is determined. These values of *P*, *Q* and *R* are kept unchanged throughout the experiment.

(*iii*) Next, the battery and galvanometer circuits are switched off and the circuits containing the A. C. source and head-phone are made by the double-way keys as shown in the figure. The variable resistance is now adjusted so that no sound is heard in the head phone.

Observations

[A] *Determination of unknown resistance X of the coil*

S. No.	P (ohm)	Q (ohm)	R (ohm)	$X = R.\frac{Q}{P}$ (ohm)

[A] (*i*) Capacity of the condenser = ... farad

(*ii*) The variable resistance r = ... *ohm*

Calculations

$$L = C\ [r\ (R+X) + QR] = \ldots \text{ henry.}$$

% *error* :

Result

The self inductone of the coil (correct to significant figures) is found to be ... henry

Precautions

(*i*) All resistances used in the experiment should be non-inductive. Connecting wires should not be coiled but they should be short and straight.

(*ii*) Once the balance has been obtained with direct current, the adjusted values of P, Q, and R should be kept. unchanged while finding the balance with alternating current.

(*iii*) Sometimes, the minimum sound in the head-phone is not sharp for a particular value of r but it spreads over a small region. The mean value of r in that region should be taken.

QUESTIONS

(*i*) Explain how Anderson's bridge is balanced.

(*ii*) Define impedance and time constant of an A. C. circuit.

(*iii*) Why should you use a variable resistance r ?

(*iv*) On what factors does the self-inductance of a coil depend ?

Exp. 61. Self-inductance of a coil by Releigh's method

Object

To determine the self-inductance of a coil by Raleigh's method.

Apparatus

P. O. Box, or meter bridge, ballistic galvanometer with lamp and scale arrangement, small standard resistances or decimal ohm box, platinoid wire (if P. O. Box is used), rheostats, double key, commutator and stop-watch.

Theory

The experimental arrangement is based on the principle of Wheatstone's bridge, the galvanometer used being a ballistic one. In fig. 61.1 the arm CD contains an unknown inductance L in series with a small standard resistance r. The resistance r is short circuited by a key K and the bridge is balanced for steady current by adjusting the resistance QR.