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B. Sc. Part II

Paper IV

Current electricity

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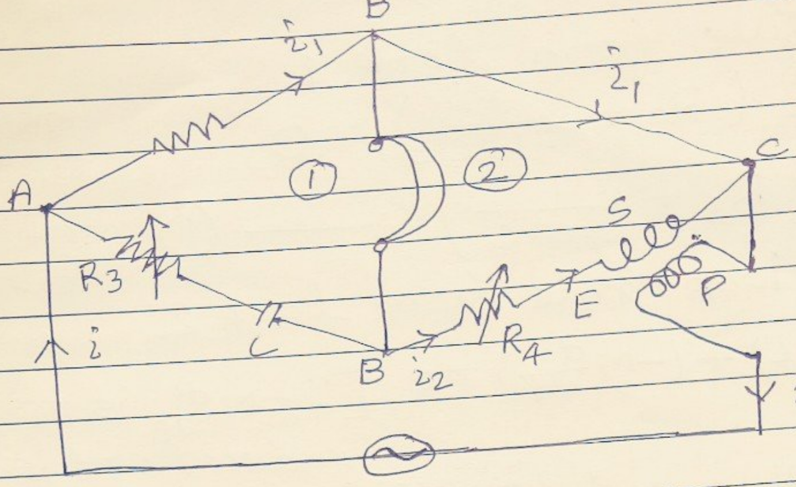
Current electricity.

Teacher's Signature:

Expt. No. Carey Foster's Bridge :-



This bridge measures the mutual inductance between two coils in terms of standard capacitance and two known non-inductive resistances. In fact is not desirable to classify this as a bridge, but it is usual practice. Here the 2nd arm BC is shorted by a thick wire. One of the coils says of the mutual inductor is placed in the 4th arm DC through a variable non-inductive resistance R_4. The first arm AB is a non-inductive resistance R_1 and the 3rd arm AD contains the standard capacitor C and a variable non-inductive resistance R_3. The other coil P of the mutual inductor is connected in series with the source. The balance condition is not given by the usual general condition for balance of an A.C. bridge.

Let i be the instantaneous current in the source branch, i_1 through R_1 and R_2

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in ADC branch at balance of the bridge. By Kirchhoff's Point rule, we have

$$i = i_1 + i_2$$

By loop rule from loop 1

$$R_1 i_1 - i_2 \left(R_3 + \frac{1}{j\omega C} \right) = 0$$

$$R_1 i_1 = i_2 \left(R_3 + \frac{1}{j\omega C} \right) \quad \text{—— (1)}$$

By loop rule from loop 2

$$i_2 (R_4 + j\omega L) + \left(-M\frac{di}{dt}\right) = 0 \quad \left[\because -M\frac{di}{dt} \text{ is the mutual induced emf is S}\right]$$

or $i_2 (R_4 + j\omega L) = M\frac{d}{dt}\left(\tilde{I} e^{j\omega t}\right) = j\omega M i$

or $i_2 (R_4 + j\omega L) = j\omega M (i_1 + i_2) \quad [\because i = i_1 + i_2]$

or $i_2 (R_4 + j\omega L - j\omega M) = j\omega M i_1 \quad \text{—— (2)}$

Substituting the value of i_1 from (i) an (ii) we have

$$i_2 (R_4 + j\omega L - j\omega M) = j\omega M \cdot \frac{i_2}{R_1} \left(R_3 + \frac{1}{j\omega C} \right)$$

or $R_4 + j\omega (L - M) = \dfrac{j\omega M R_3}{R_1} + \dfrac{M}{C R_1}$

equating real parts $R_4 = \dfrac{M}{C R_1}$

or $M = R_1 R_4 C \quad \text{—— (a)}$

equating imaginary parts $L - M = \dfrac{M R_3}{R_1}$

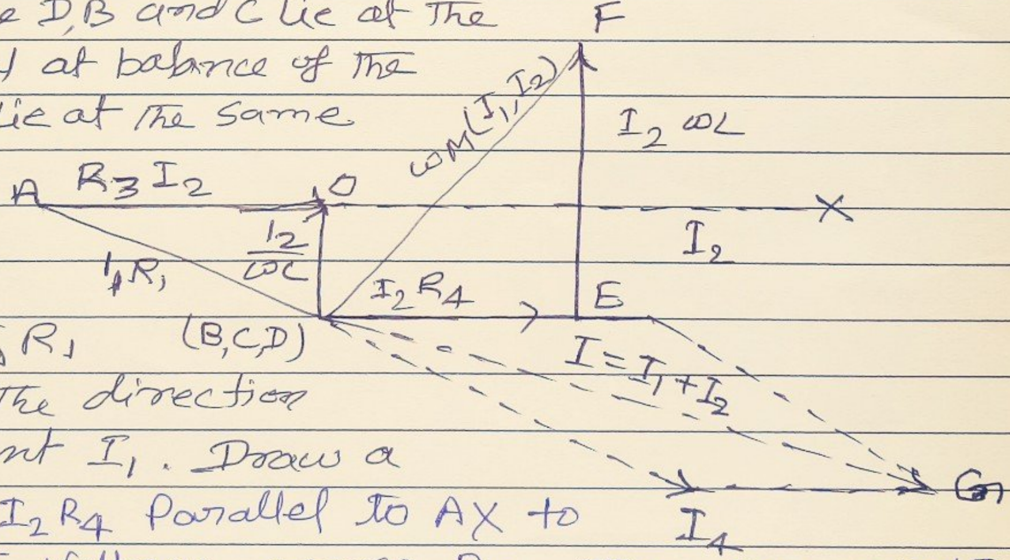
or $L = M \left(1 + \dfrac{R_3}{R_1} \right) \quad \text{—— (b)}$

The two balance conditions are independent of one another. changing R_1 the first condition is achieved and changing R_5 the 2nd condition is achieved.

It is to be noted carefully that the sign of M depends on the windings of Primary and Secondary and the way in which their leads are connected. If the leads are the wrong way round, then a balance is never possible. In this hard case then leads must be reversed to obtain balance.

Vector Diagram of The Bridge :-

Let AX represent the direction of current I_2 through the ADC at balance. Cut of length $AO = R_3 I_2$ to represent voltage across R_3. The voltage across C is $\frac{I_2}{\omega C}$. Since the voltage across a capacitor lags the current by $\pi/2$, draw a line $OD = I_2 \cdot 1/\omega C$ in the anticlock wise direction perpendicular to AO at O. Since D, B and C lie at the same potential at balance of the bridge, they lie at the same point in the vector diagram.



Thus $AB = I_1 R_1$ and AB is the direction of the current I_1. Draw a line $DE = I_2 R_4$ parallel to AX to represent the voltage across R_4. Then $FD = \omega M(I_1 + I_2)$. Then the direction of the total current $I = I_1 + I_2$ is a line DG perpendicular to FD at D.