**5** A potentiometer circuit that is used as a means of comparing potential differences is shown in Fig. 5.1.

For Examiner's Use

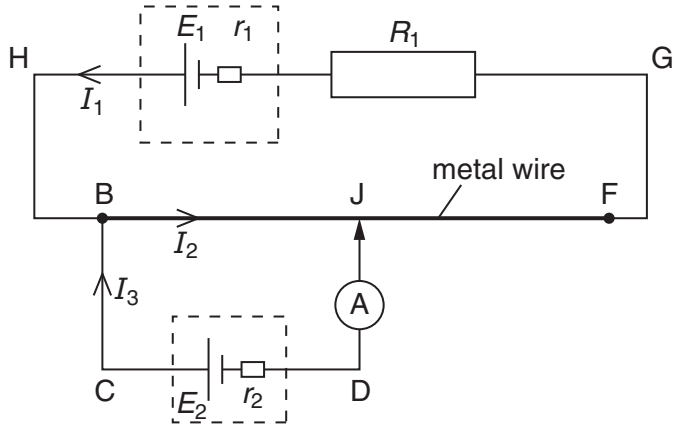


**Fig. 5.1**

A cell of e.m.f. $E_1$ and internal resistance $r_1$ is connected in series with a resistor of resistance $R_1$ and a uniform metal wire of total resistance $R_2$.
A second cell of e.m.f. $E_2$ and internal resistance $r_2$ is connected in series with a sensitive ammeter and is then connected across the wire at BJ. The connection at J is halfway along the wire. The current directions are shown on Fig. 5.1.

**(a)** Use Kirchhoff's laws to obtain the relation

**(i)** between the currents $I_1$, $I_2$ and $I_3$,

.....[1]

**(ii)** between $E_1$, $R_1$, $R_2$, $r_1$, $I_1$ and $I_2$ in loop HBJFGH,

.....[1]

**(iii)** between $E_1$, $E_2$, $r_1$, $r_2$, $R_1$, $R_2$, $I_1$ and $I_3$ in the loop HBCDJFGH.

.....[2]

**(b)** The connection at J is moved along the wire. Explain why the reading on the ammeter changes.

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.....[2]