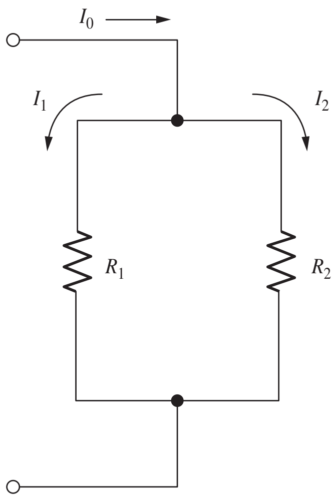

Figure 4.52.

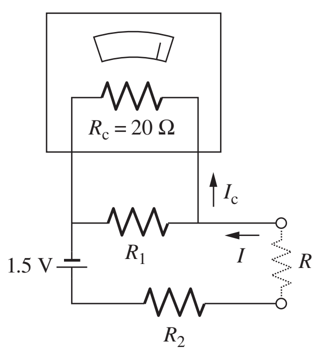

Figure 4.53.

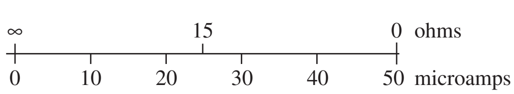

Figure 4.54.

(b) The bulbs are now connected in series, as shown in Fig. 4.51(b). Which bulb is brighter, and by what factor? How bright is each bulb compared with bulb 1 in part (a)?

4.39 *Maximum power* *

Show that if a battery of fixed emf $\mathcal{E}$ and internal resistance R_i is connected to a variable external resistance R, the maximum power is delivered to the external resistor when $R = R_i$.

4.40 *Minimum power dissipation* **

Figure 4.52 shows two resistors in parallel, with values R_1 and R_2. The current I_0 divides somehow between them. Show that the condition that $I_1 + I_2 = I_0$, together with the requirement of *minimum power dissipation*, leads to the same current values that we would calculate with ordinary circuit formulas. This illustrates a general variational principle that holds for direct current networks: the distribution of currents within the network, for given input current I_0, is always that which gives the *least* total power dissipation.

4.41 *D-cell* **

The common 1.5 volt dry cell used in flashlights and innumerable other devices releases its energy by oxidizing the zinc can which is its negative electrode, while reducing manganese dioxide, MnO_2, to Mn_2O_3 at the positive electrode. (It is called a carbon–zinc cell, but the carbon rod is just an inert conductor.) A cell of size D, weighing 90 g, can supply 100 mA for about 30 hours.

(a) Compare its energy storage, in J/kg, with that of the lead–acid battery described in the example in Section 4.9. Unfortunately the cell is not rechargeable.

(b) How high could you lift yourself with one D-cell powering a 50 percent efficient winch?

4.42 *Making an ohmmeter* ***

You have a microammeter that reads 50 μA at full-scale deflection, and the coil in the meter movement has a resistance of 20 ohms. By adding two resistors, R_1 and R_2, and a 1.5 volt battery as shown in Fig. 4.53, you can convert this into an ohmmeter. When the two outcoming leads of this ohmmeter are connected together, the meter is to register zero ohms by giving exactly full-scale deflection. When the leads are connected across an unknown resistance R, the deflection will indicate the resistance value if the scale is appropriately marked. In particular, we want half-scale deflection to indicate 15 ohms, as shown in Fig. 4.54. What values of R_1 and R_2 are required, and where on the ohm scale will the marks be (with reference to the old microammeter calibration) for 5 ohms and for 50 ohms?