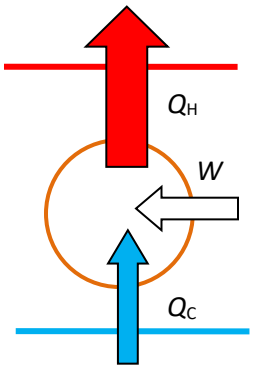
Teacher notes
Topic B

So you bought a Carnot air conditioner!

In hot places around the world, air conditioners are used to cool a room down. Suppose you bought a Carnot air conditioner, i.e. one whose working cycle is the Carnot cycle. Heat must be extracted from a room at a rate of 1.6 kW in order to keep the room at a comfortable temperature of $22\ ^\circ\text{C}$ when the outside temperature is an unbearable $40\ ^\circ\text{C}$.

What power is required to run the air conditioner?

We know that $Q_C + W = Q_H$. Since $\frac{Q_C}{Q_H} = \frac{T_C}{T_H}$ we have that $Q_C + W = Q_C \frac{T_H}{T_C}$.



This gives

$$W = Q_C\left(\frac{T_H}{T_C} - 1\right)$$

$$= Q_C \frac{T_H - T_C}{T_C} \quad \text{so} \quad P = P_C \frac{T_H - T_C}{T_C}$$

$$P = 1.6 \times 10^3 \times \frac{18}{295} = 98\,\text{W}$$

This is a very small input power (which is what you pay for) and so looks attractive. This has to do with the fact that the temperature difference between the cold and hot reservoirs is small. However, as noted in the textbook, Carnot engines are not practical since their isothermal sections would have to be traversed very slowly making each cycle too long.