Given:

A Peltier cooler uses 50 W of power to absorb 500 W of heat from a cold temperature source.

$$W'_{in} := 50W \qquad Q'_L := 500W$$

Required:

If the external warm temperature is 85°F, what is the coldest temperature the source could be?

Solution:

The warm temperature is defined as

$$T_H := 85\,°F$$

In this configuration, the Peltier cooler behaves as a refrigerator. Thus the COP is given by

$$COP_R := \frac{Q'_L}{W'_{in}} = 10$$

For this to be a real device, the COP must be great than or equal to the COP of the Carnot cycle. Remember the Carnot cycle COP is given by

$$COP_{rev} = \frac{T_L}{T_H - T_L}$$

Inspecting the expression shows that a decrease in the low temperature source will decrease the COP. Thus, the coldest that the low temperature source may be for this system may be found by setting the Carnot cycle COP equal to the actual COP. This is shown below.

$$COP_R = COP_{rev} = \frac{T_L}{T_H - T_L} \qquad \text{or} \qquad \boxed{T_L := \frac{COP_R \cdot T_H}{COP_R + 1} = 35.5 \cdot °F}$$