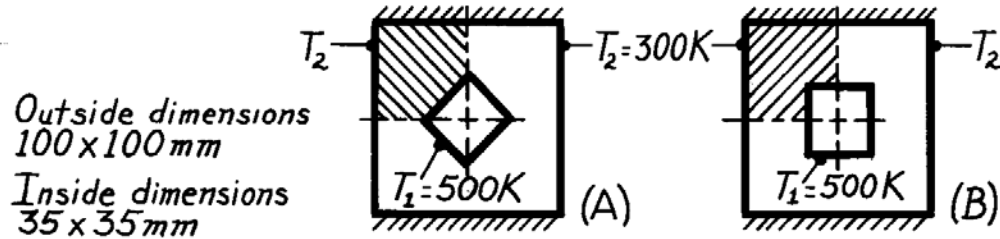## PROBLEM 4S.7

KNOWN: Hollow prismatic bars fabricated from plain carbon steel, 1m in length with prescribed temperature difference.

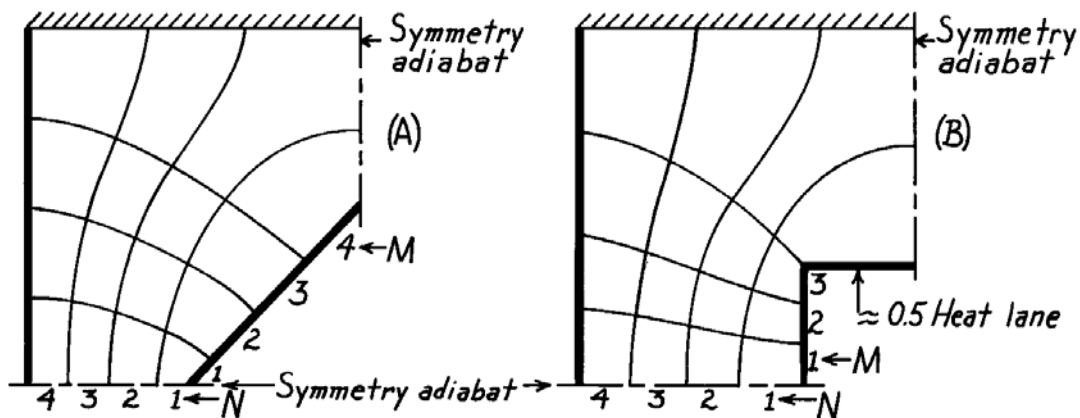**FIND:** Shape factors and heat rate per unit length.

SCHEMATIC:

ASSUMPTIONS: (1) Steady-state conditions, (2) Two-dimensional conduction, (3) Constant properties.

PROPERTIES: *Table A-1*, Steel, Plain Carbon (400K), k = 57 W/m·K.

ANALYSIS: Construct a flux plot on the symmetrical sections (shaded-regions) of each of the bars.

The shape factors for the symmetrical sections are,

$$S_{o,A} = \frac{M\ell}{N} = \frac{4}{4}\ell = 1\ell \qquad S_{o,B} = \frac{M\ell}{N} = \frac{3.5}{4}\ell = 0.88\ell.$$

Since each of these sections is ¼ of the bar cross-section, it follows that

$$S_A = 4\times1\ell = 4\ell \qquad\qquad S_B = 4\times0.88\ell = 3.5\ell. \qquad\qquad <$$

The heat rate per unit length is $q' = q/\ell = k(S/\ell)(T_1 - T_2)$,

$$q'_A = 57\frac{W}{m\cdot K}\times4(500-300)\,K = 45.6\ \text{kW/m} \qquad\qquad <$$

$$q'_B = 57\frac{W}{m\cdot K}\times3.5(500-300)\,K = 39.9\ \text{kW/m}. \qquad\qquad <$$