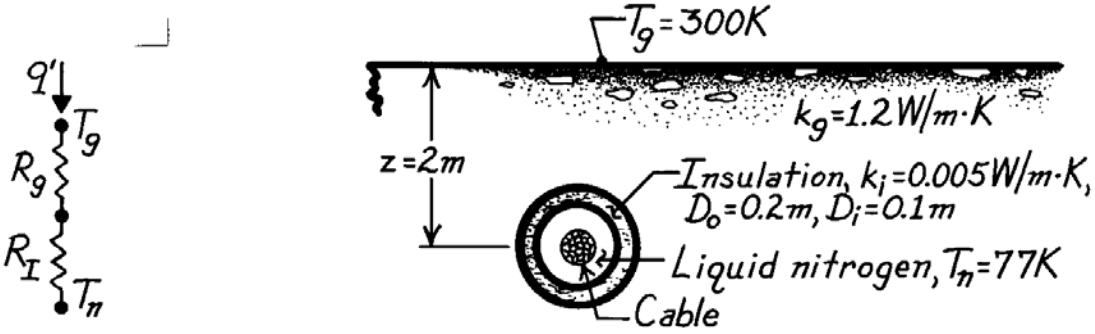
PROBLEM 4.24

KNOWN: Operating conditions of a buried superconducting cable.

FIND: Required cooling load.

SCHEMATIC:



ASSUMPTIONS: (1) Steady-state conditions, (2) Constant properties, (3) Two-dimensional conduction in soil, (4) One-dimensional conduction in insulation, (5) Pipe inner surface is at liquid nitrogen temperature.

ANALYSIS: The heat rate per unit length is

$$q' = \frac{T_g - T_n}{R'_g + R'_I}$$

$$q' = \frac{T_g - T_n}{\left[k_g\left(2\pi/\ln\left(4z/D_o\right)\right)\right]^{-1} + \ln\left(D_o/D_i\right)/2\pi\ k_i}$$

where Tables 3.3 and 4.1 have been used to evaluate the insulation and ground resistances, respectively. Hence,

$$q' = \frac{(300-77)\,\mathrm{K}}{\left[(1.2\ \mathrm{W/m\cdot K})\left(2\pi/\ln\left(8/0.2\right)\right)\right]^{-1} + \ln(2)/2\pi \times 0.005\ \mathrm{W/m\cdot K}}$$

$$q' = \frac{223\ \mathrm{K}}{(0.489+22.064)\,\mathrm{m\cdot K/W}}$$

$$q' = 9.9\ \mathrm{W/m}. \qquad <$$

COMMENTS: The heat gain is small and the dominant contribution to the thermal resistance is made by the insulation.