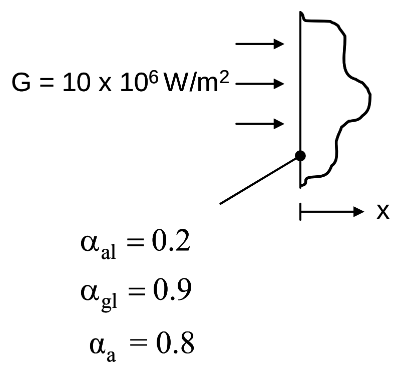
PROBLEM 2.9

KNOWN: Irradiation and absorptivity of aluminum, glass and aerogel.

FIND: Ability of the protective barrier to withstand the irradiation in terms of the temperature gradients that develop in response to the irradiation.

SCHEMATIC:



ASSUMPTIONS: (1) One-dimensional conduction in the x-direction, (2) Constant properties, (c) Negligible emission and convection from the exposed surface.

PROPERTIES: Table A.1, pure aluminum (300 K): k_{al} = 238 W/m·K. Table A.3, glass (300 K): k_{gl} = 1.4 W/m·K.

ANALYSIS: From Eqs. 1.6 and 2.32

$$-k\left.\frac{\partial T}{\partial x}\right|_{x=0} = q_s'' = G_{abs} = \alpha G$$

or

$$\left.\frac{\partial T}{\partial x}\right|_{x=0} = -\frac{\alpha G}{k}$$

The temperature gradients at x = 0 for the three materials are: <

Material	$\partial T / \partial x\|_{x=0}$ (K/m)
aluminum	8.4×10^3
glass	6.4×10^6
aerogel	1.6×10^9

COMMENT: It is unlikely that the aerogel barrier can sustain the thermal stresses associated with the large temperature gradient. Low thermal conductivity solids are prone to large temperature gradients, and are often brittle.