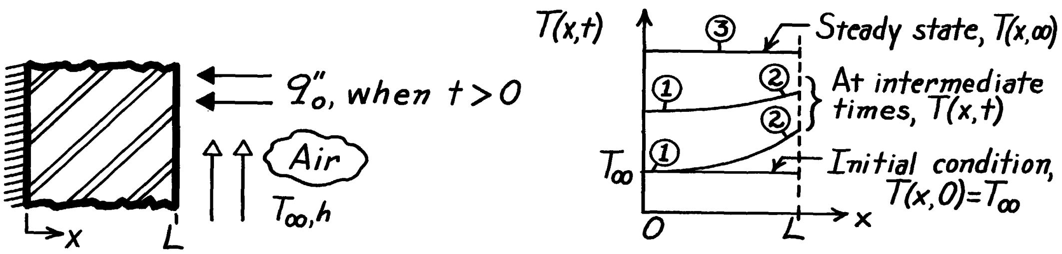
PROBLEM 5.2

KNOWN: Plane wall whose inner surface is insulated and outer surface is exposed to an airstream at T_∞. Initially, the wall is at a uniform temperature equal to that of the airstream. Suddenly, a radiant source is switched on applying a uniform flux, q_o'', to the outer surface.

FIND: (a) Sketch temperature distribution on T-x coordinates for initial, steady-state, and two intermediate times, (b) Sketch heat flux at the outer surface, $q_x''(L,t)$, as a function of time.

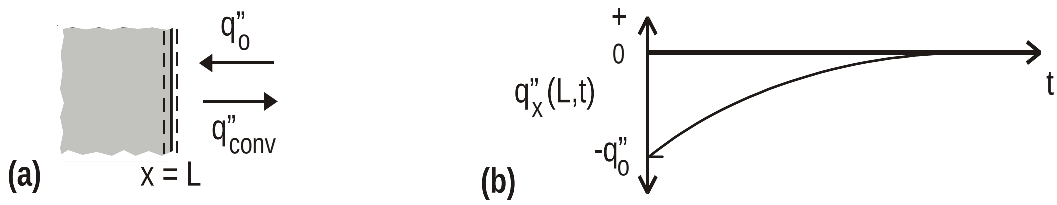
SCHEMATIC:



ASSUMPTIONS: (1) One-dimensional conduction, (2) Constant properties, (3) No internal generation, $\dot{E}_g = 0$, (4) Surface at x = 0 is perfectly insulated, (5) All incident radiant power is absorbed and negligible radiation exchange with surroundings.

ANALYSIS: (a) The temperature distributions are shown on the T-x coordinates and labeled accordingly. Note these special features: (1) Gradient at x = 0 is always zero, (2) gradient is more steep at early times and (3) for steady-state conditions, the radiant flux is equal to the convective heat flux (this follows from an energy balance on the CS at x = L),

$q_o'' = q_{conv}'' = h\left[T(L,\infty) - T_\infty\right].$



(b) The heat flux at the outer surface, $q_x''(L,t)$, as a function of time appears as shown above.

COMMENTS: The sketches must reflect the initial and boundary conditions:

$T(x,0) = T_\infty$	uniform initial temperature.
$-k\frac{\partial T}{\partial x}\Big\vert_{x=0} = 0$	insulated at x = 0.
$-k\frac{\partial T}{\partial x}\Big\vert_{x=L} = h\left[T(L,t) - T_\infty\right] - q_o''$	surface energy balance at x = L.