switch is usually an electronic switch (e.g., a transistor—see Chapter 10) and can be treated as an ideal switch. The circuit on the left represents the ignition circuit immediately after the electronic switch has closed, following a spark discharge. Thus, one can assume that no energy is stored in the inductor prior to the switch closing, say at $t = 0$. Furthermore, no energy is stored in the capacitor, as the short circuit (closed switch) across it would have dissipated any charge in the capacitor. The primary winding of the ignition coil (left-hand side inductor) is then given a suitable length of time to build up stored energy, and then the switch opens, say at $t = \Delta t$, leading to a rapid voltage buildup across the secondary winding of the coil (right-hand side inductor). The voltage rises to a very high value because of two effects: the *inductive voltage kick* described in Example 5.11 and the voltage multiplying effect of the transformer. The result is a very short high-voltage transient (reaching thousands of volts), which causes a spark to be generated across the spark plug.

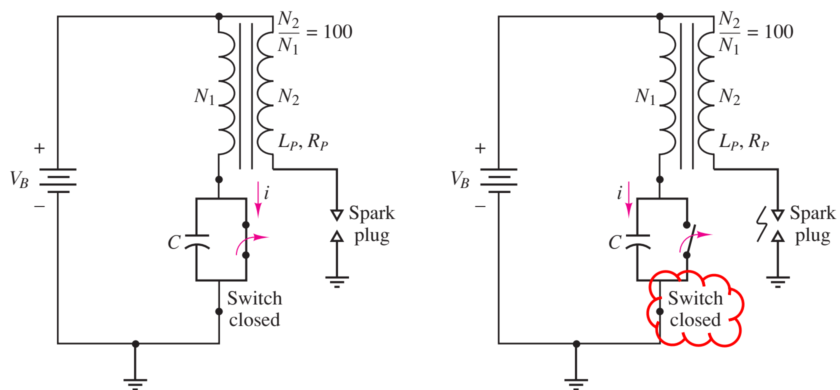

Figure 5.56

Solution

Known Quantities: Battery voltage, resistor, capacitor, inductor values.

Find: The ignition coil current $i(t)$ and the open-circuit voltage across the spark plug $v_{OC}(t)$.

Schematics, Diagrams, Circuits, and Given Data: $V_B = 12$ V; $R_p = 2\ \Omega$; $C = 10\ \mu$F; $L_p = 5$ mH.

Assumptions: The switch has been open for a long time, and it closes at $t = 0$. The switch opens again at $t = \Delta t$.

Analysis: Assume that initially no energy is stored in either the inductor or the capacitor, and that the switch is closed, as shown in Figure 5.57(a). When the switch is closed, a first-order circuit is formed by the primary coil inductance and capacitance. The solution of this circuit will now give us the initial condition that will be in effect when the switch is ready to open again. This circuit is identical to that analyzed in Example 5.9, and we can directly borrow the solution obtained from that example, after suitably replacing the final value and time constant:

$$i_L(t) = i_L(\infty) + [i_L(0) - i_L(\infty)]e^{-t/\tau} \qquad t \geq 0$$

$$i_L(t) = 6(1 - e^{-t/2.5\times10^{-3}}) \qquad t \geq 0$$