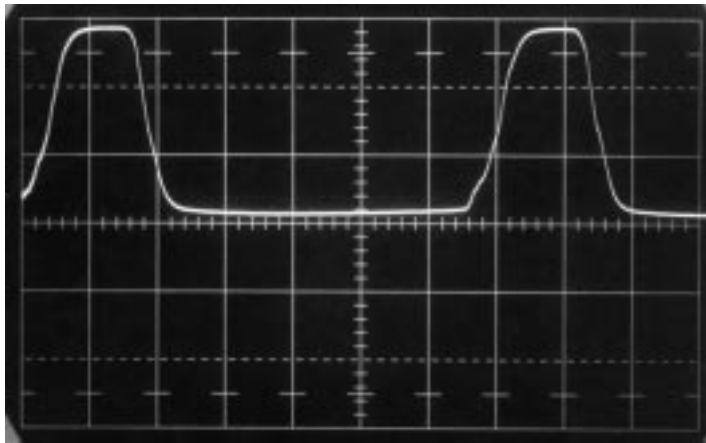
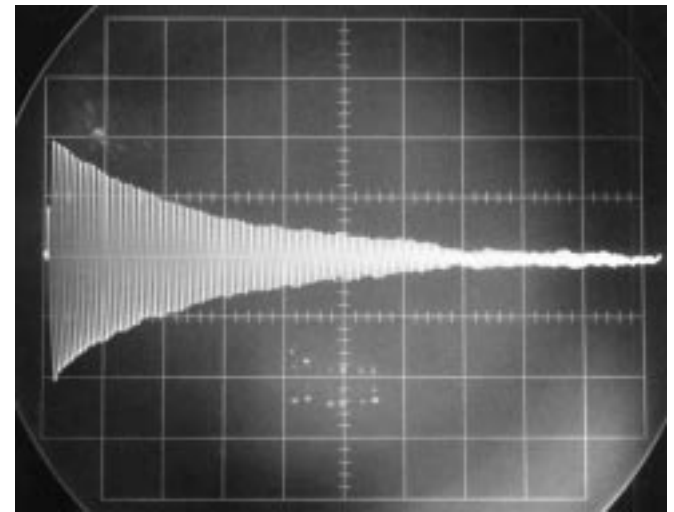


Figure 5



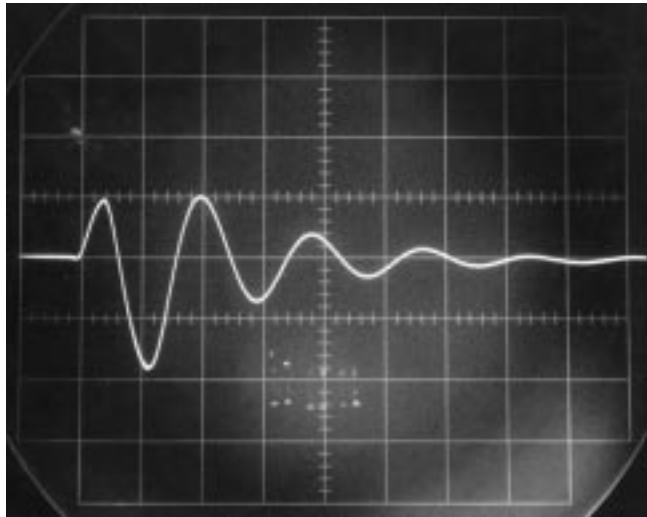
(a) 50 mSEC/DIV



10 mV/DIV

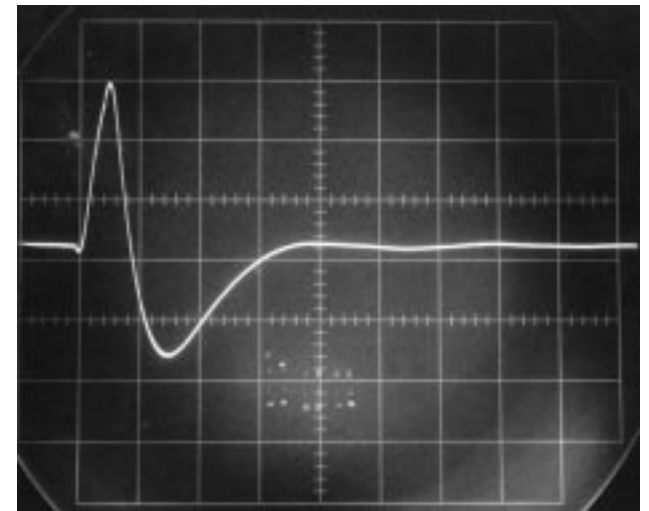
(b)

12 SEC/DIV



10 mV/DIV

(c) 0.5 SEC/DIV



10 mV/DIV

(d)

0.5 SEC/DIV

Deliberate excess of loop gain-bandwidth introduces large-signal oscillation, and the duty cycle reveals asymmetric gains for heating and cooling modes (a). When gain-bandwidth is still excessively high, the loop response to a small step in the temperature setpoint results in a damped, ringing response of greater than 2 minutes in duration (b). After reducing the loop gain-bandwidth, the response isn't yet optimal, but settling occurs in 4.5 seconds (c). Gain-bandwidth optimization results in nearly critically damped response with settling in 2 seconds (d).