

$$\omega_o = \left[ \frac{1}{R_5 C_3 C_4} \left( \frac{1}{R_1} + \frac{1}{R_2} \right) \right]^{1/2}$$

$$\frac{1}{Q} = \alpha = \sqrt{\frac{1}{R_5 (1/R_1 + 1/R_2)}} \left[ \sqrt{\frac{C_3}{C_4}} + \sqrt{\frac{C_4}{C_3}} \right]$$

$$\phi = \pi + \phi_{BP}$$

$$\tau = \tau_{BP}$$

Tuning this filter appears rather formidable. In practice  $R_1 \gg R_2$  and so  $R_2$  can be used to trim the  $Q$ . Then, to adjust the center frequency,  $R_2$  and  $R_5$  can be simultaneously adjusted by the same percentage with negligible effect on the  $Q$ .

The sensitivities of the network parameters with respect to the elements are

$$S_{R_5}^{\omega_o} = S_{C_3}^{\omega_o} = S_{C_4}^{\omega_o} = -\frac{1}{2}$$

$$S_{R_1}^{\omega_o} = \frac{-1}{2\omega_o^2 R_1 R_5 C_3 C_4}$$

$$S_{R_2}^{\omega_o} = \frac{-1}{2\omega_o^2 R_2 R_5 C_3 C_4}$$

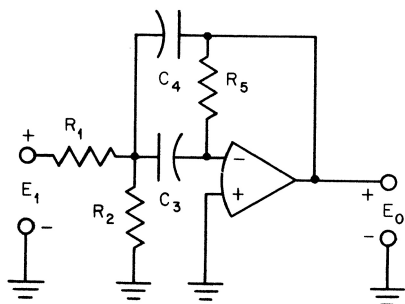
$$S_{R_1}^Q = \frac{R_1}{2(R_1 + R_2)} - \frac{1}{2}$$

$$S_{R_2}^Q = \frac{R_2}{2(R_1 + R_2)} - \frac{1}{2}$$

$$S_{R_5}^Q = \frac{1}{2}$$

$$S_{C_3}^Q = \frac{Q}{\omega_o R_5 C_3} - \frac{1}{2}$$

$$S_{C_4}^Q = \frac{Q}{\omega_o R_5 C_4} - \frac{1}{2}$$



**Fig. 8.5** Multiple-feedback bandpass filter.