A symmetrical crystalline materials such as Quartz, Rochelle salt and Barium titanate produce an emf when they are placed under stress. This property is used in piezo electric transducers, where a crystal is placed between a solid base and the force-summing member, as shown in Fig. 13.32.

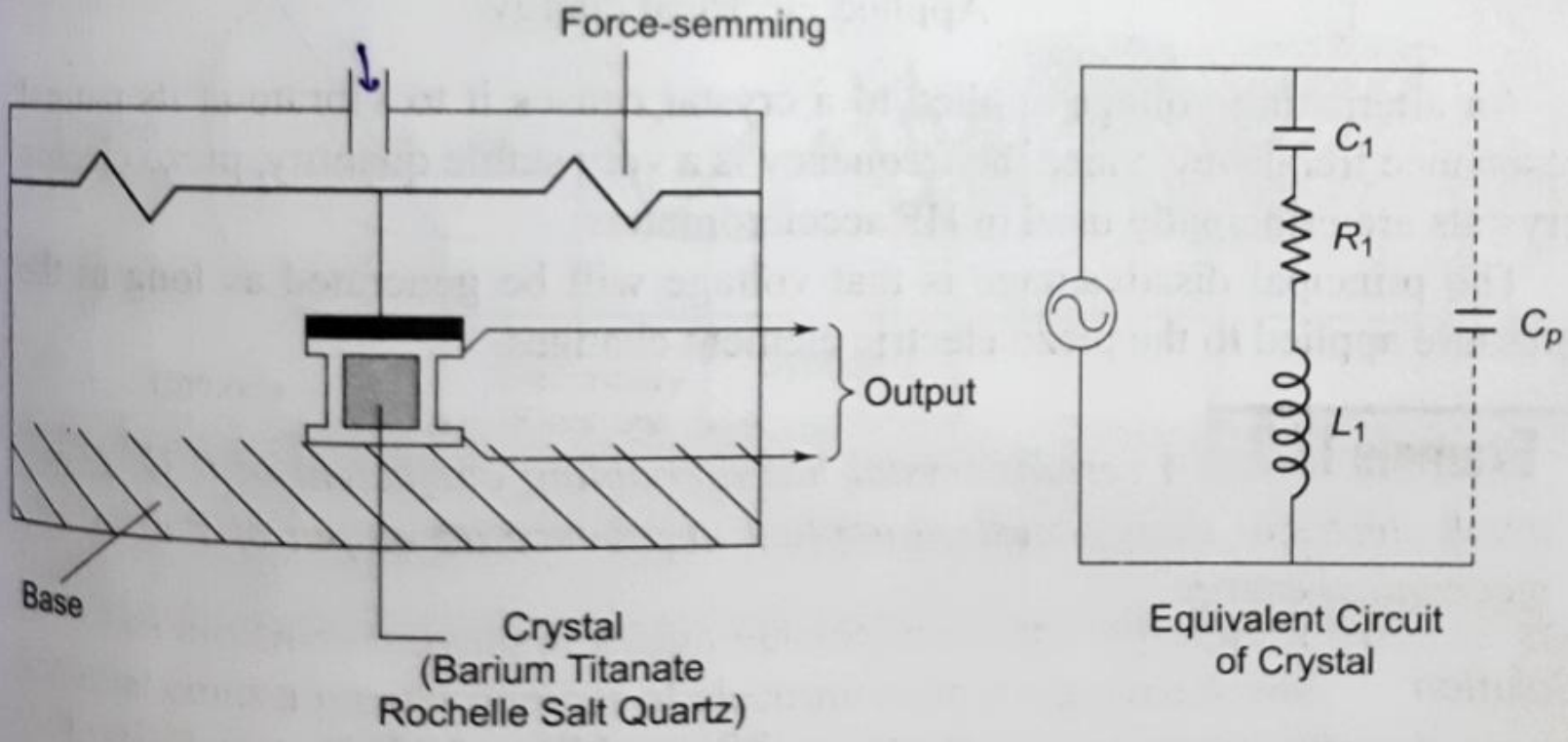

Fig. 13.32 Piezo electric transducer

An externally applied force, entering the transducer through its pressure port, applies pressure to the top of a crystal. This produces an emf across the crystal proportional to the magnitude of applied pressure.

Since the transducer has a very good HF response, its principal use is in HF accelerometers. In this application, its output voltage is typically of the order of 1 – 30 mV per gm of acceleration. The device needs no external power source and is therefore self generating. The disadvantage is that it cannot measure static conditions. The output voltage is also affected by temperature variation of the crystal. The basic expression for output voltage E is given by

$$E = \frac{Q}{C_p}$$

where Q = generated charge
C_p = shunt capacitances

This transducer is inherently a dynamic responding sensor and does not readily measure static conditions. (Since it is a high impedance element, it requires careful shielding and compensation.)

For a piezo electric element under pressure, part of the energy is converted to an electric potential that appears on opposite faces of the element, analogous to a charge on the plates of a capacitor. The rest of the applied energy is converted to mechanical energy, analogous to a compressed spring. When the pressure is removed, it returns to its original shape and loses its electric charge.

From these relationships, the following formulas have been derived for the coupling coefficient K.

$$K = \frac{\text{Mechanical energy converted to electrical energy}}{\text{Applied mechanical energy}}$$

or

$$K = \frac{\text{Electrical energy converted to mechanical energy}}{\text{Applied electrical energy}}$$

An alternating voltage applied to a crystal causes it to vibrate at its natural resonance frequency. Since the frequency is a very stable quantity, piezo electric crystals are principally used in HF accelerometers.

The principal disadvantage is that voltage will be generated as long as the pressure applied to the piezo electric element changes.