ACOUSTO-OPTIC DEFLECTION TRANSDUCERS

The acousto-optic (AO) deflection transducer, aside from other applications is used to detect physical vibrations by converting them into a corresponding phase-modulated electronic signal. The primary mechanism is the interaction of an optical wave (photons) with an acoustic wave (phonons), to produce a new optical wave (photons).

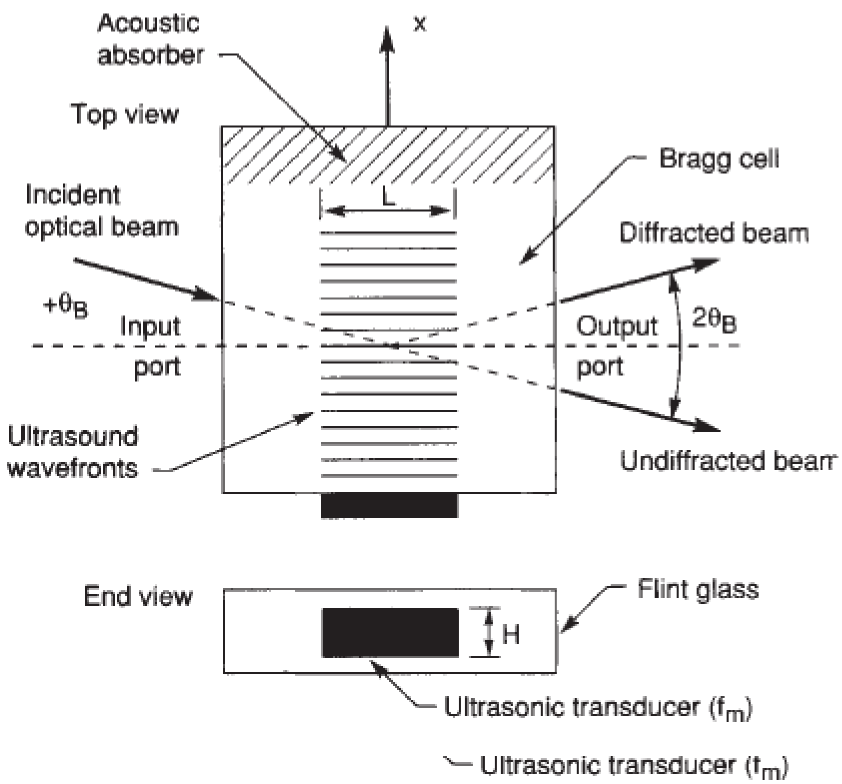

Fig 5.41 Acoustooptic deflection transducer.

Figure 5.41a shows diagrammatically an acoustooptic interaction cell, also known as the Bragg cell. It consists of a solid piece of optical-quality flint glass which acts as the interaction medium. It has optical windows on two opposite sides which serve as ports for the entry and exit of the optical beam.

A high-frequency ultrasound transducer is bonded to one of the two remaining sides. The ultrasound transducer launches longitudinal waves in the interaction region and produces regions of compression and rarefaction, which are regions of varying refractive index. These regions are equivalent to a three-dimensional diffraction grating.

An optical (laser) beam entering the Bragg cell at an angle ɵ and passing through the length L of the grating experiences the periodic changes in the refractive index at the excitation frequency ώm of the ultrasonic transducer.

Consequently, the optical beam leaving the cell is phase-modulated and consists of an optical carrier at ώc and pairs of optical sidebands around ώc, at ώc, ±N_m, where N is an integer corresponding to the order of the sidebands.There is a unique value of ɵ= ɵB corresponding to the optical wavelength λ and the acoustic wavelength , when only one of the first-order sidebands grows by constructive interference and the other, along with all the higher sidebands, diminishes owing to destructive interference.

This is known as the Bragg effect, and ɵB is called the Bragg angle. The angle is given by the Bragg diffraction equation

$$\sin\theta_B = \frac{\lambda}{2\Lambda} = \frac{\lambda}{2v_m} f_m$$

Where m is the ultrasound velocity in the medium and fm is the ultrasonic modulation frequency of the _n wave. The angle between the Bragg deflected beam and the carrier is 2B.

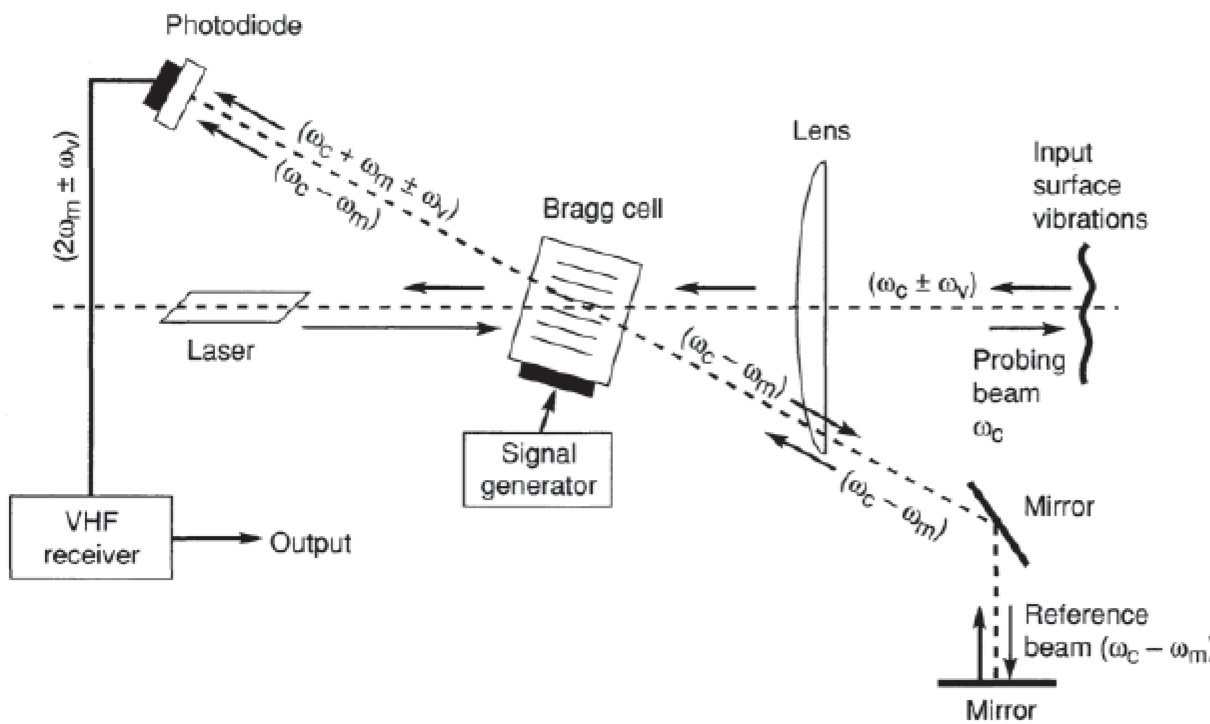

Fig 5.42 Noncontact vibration-measuring setup using a Bragg cell.

Figure 5.42 shows an application where the Bragg cell is used as a noncontact vibration-measuring transducer.98 A He-Ne laser is used as the source of the optical beam. The Bragg cell is used to measure the surface vibrations. On the face of the photodiode, the demodulation of the optical signals takes place.

The output current of the photodiode has a component at (2_m+_). The VHF receiver measures the sideband amplitude, which is proportional to the amplitude of the surface vibrations.