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Acoustic Investigation of Cochlear Activity

D. T. KEMP

Royal National Throat, Nose & Ear Hospital, London

The ear drum, middle ear and cochlea form a closely coupled mechanical system. It follows that ear drum dynamics is significantly dependent upon the mechanical input impedance of the cochlea. An acoustic investigation technique developed for monitoring certain aspects of cochlear mechanics from the meatus will be discussed and the somewhat surprising results obtained will be reviewed. (Kemp 1978, 1979 a & b).

Classical models of the simplified cochlea show it to act as a transmission line for transverse waves launched on the basilar membrane by the piston action of the stapes. The lines cut off frequency decreases smoothly but rapidly with distance along the membrane so that at all but the very lowest frequencies the energy stored in the travelling wave is totally absorbed and none is returned to the input. The functional component of the cochlear input impedance should thus be resistive. In this case it would act as a damping element on the middle ear. The cochlear element of middle ear damping is not easily distinguishable from other sources but experiments have been undertaken to isolate and measure this component. (Zwislocki, 1962). These experiments appeared to confirm the resistive nature of the cochlear load.

In the real cochlea the basilar membrane is mechanically loaded by the organ of Corti which is responsible for the final stage of frequency selectivity and the activation of auditory nerve fibres. Classical models implicitly assume that this mechanical loading is both linear and passive. In practice it is not. The result is a perturbation of cochlear mechanics. Energy is returned to the input under certain conditions causing significant nonlinear and frequency dependent reactive components to appear in the cochlear input impedance. These features are readily observed and distinguished from middle ear parameters with the new acoustic measurements of ear canal response. Thus whilst the primary resistive component of gross cochlear mechanics cannot be studied from the ear canal, the secondary, and potentially more interesting components can.

Nonlinear and active mechanical processes in the cochlea appear to be related to the normal functioning of the transduction and second filtering mechanism and share the same vulnerability to cochlear disease, over-stimulation and ototoxic drugs (Anderson & Kemp, 1979). This mechanism is not yet fully understood. The cochlea reverts to a passive, linear state if its normal function is disturbed.

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