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Auditory considerations

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auditory canal to behave much like an organ pipe closed at one end. The combined effects of head, ear canal and termination on the ratio of the pressure at the eardrum to the external pressure measured in a free field are illustrated by Fig. 5 [21]. Varying with frequency, this ratio reaches its largest values in the region above 1000 cycles. This

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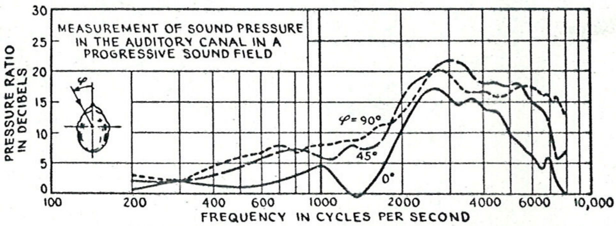

Fig. 5. Sound pressure at ear drum compared with sound pressure in free sound field at position corresponding to center of observer's head. The average result for 6–12 male ears is shown for three different azimuths (WIENER and ROSS [21]).

quantitative example of transmission characteristics is the only one which is included here. It is presented merely as tangible proof that the auditory system can not be regarded as a distortionless transmission system.

Added to the above effects are the transmission characteristics of the middle ear. Here the eardrum, ossicles and oval window act together somewhat like an electrical transformer to reduce the large impedance discontinuity which would exist if sound waves in air were to act directly on the dense fluids of the cochlea [18], [22], [23]. This action is due mainly to the relative areas of the large eardrum and tiny oval window. Were it not modified by other factors it would cause any pressure on the eardrum to be stepped up, independently of frequency, to much greater pressures on the cochlear fluids. However, such factors as the masses of the eardrum and ossicles and the elastic constants of various components, such as the air chamber behind the eardrum and the ligaments and tissues which hold the drum and ossicles in place, introduce a frequency effect in the above transfer of pressure through the middle ear. This effect appears to be in the direction of accentuating frequencies within a region ranging roughly from 1000 to 3000 cycles [14], [22].

Measurements by BÉKÉSY [24] on actual cochleas and theoretical studies by ZWISLOCKI [31], [32], PETERSON and BOGERT [33] and FLETCHER [34] have provided a good picture of the movements within the cochlea.