Chapter 14

Infrasound

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With 16 Figures

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I. Introduction

Human beings ordinarily detect only a small portion of the sound energy to which they are exposed. Indeed, sound is usually defined in terms of the limited range of frequencies to which the human ear readily responds — the "audio-frequency" range. However, sound energy at frequencies below this audio-

E. de Boer et al., *Auditory System*

frequency range can elicit both auditory and nonauditory responses from human beings. It is energy in this infrasound range that is the focus of the present chapter. This chapter deals with air-transmitted infrasound only; structure-borne infrasound, usually described as vibration, is not included.

Although infrasound is generated by many sources both within the body and in the external environment, recent development of artificial sources that generate high levels of this energy has necessitated a detailed examination of the effects of infrasound on human beings. The initial results from various laboratories appear to present a consistent picture. While it would be unreasonable to suggest that the findings concerning infrasound have reached a maximum, suggested by VON BÉKÉSY (1974, Vol. V/1, Chapter 1) as the best time to write a handbook, the recent results dispel many of the errors and misconceptions that have been rife in the infrasound literature.

Exposure to infrasound elicits a variety of auditory and nonauditory responses. At threshold, the observer initially becomes aware of an intermittent chugging or motorboating sound. As stimulus intensity is increased, observers consistently report a sensation of pressure build-up in the middle ear. The pressure sensation appears related to tympanic membrane retraction and vascular infusion into the blood vessels of the tympanic membrane. The observers may also detect vibration of hair or clothing as well as a modulation of vocal signals at these infrasound levels. Further increases in intensity may result in pain, damage to middle ear structures, and temporary or permanent hearing loss.

The substantive material to be considered in this chapter is organized into seven main sections. Section II briefly reviews environmental and physiological infrasound sources as well as laboratory simulators. Some of the difficulties in measuring infrasound are also considered. Section III includes a discussion of the biomechanical principles of infrasound reception and a brief examination of external, middle, and inner ear responses. Direct auditory responses to infrasound (thresholds, loudness, and masking) are summarized in Section IV; damage to the ear associated with high intensity infrasound stimulation is also considered. Section V deals with the changes in audiofrequency sound reception due to the simultaneous presence of infrasound and/or static pressure. The effect of modulating an audiofrequency sound at an infrasound frequency is discussed briefly. Indirect auditory responses to infrasound are presented in Section VI. Included in this section are those responses which are mediated by the cochlea but which are not themselves primarily auditory. Indirect auditory responses can be physiological, such as cardiovascular and endocrine changes, or behavioral, such as disturbances of complex task performance and annoyance. By stimulating structures other than the cochlea, infrasound can elicit nonauditory responses; vestibular and respiratory nonauditory responses to infrasound are summarized in Section VII. The infrasound effects similar to those produced by structure-borne vibration are also examined in Section VII. Finally, proposed exposure limits for infrasound are presented in Section VIII.

The information considered in this chapter provides support for three basic points concerning infrasound. First, contrary to the statements contained in most treatments of hearing and a definition of the term itself, infrasound can produce