The contraction of the middle ear muscles occurs bilaterally even when elicited by an acoustic stimulus to only one ear. In animals such as cats and rabbits, both middle ear muscles, the m. tensor tympani and m. stapedius, are activated in this reflex. The threshold of the m. tensor tympani contraction is usually higher than that of the m. stapedius. In either case, the threshold is well above the threshold of hearing. In man, the contraction of the m. stapedius was first shown by Lüscher...
(1929) who observed the contraction visually through a small hole in the ear-drum. Only the m. stapedius seems to be activated by sound in man (Jepsen, 1955) unless the sound gives rise to a more general type of motor response such as the startle reaction (Djupesland, 1967).

The middle ear muscles in man and in other mammals can also be activated by certain nonacoustic stimuli. Closing of the eyes (Metz, 1951) and forced air stimulation of the orbital region (Klockhoff and Andersson, 1960; Klockhoff 1961) as well as stimulation of the skin on or around the external ear in the ear canal can elicit contraction of the middle ear muscles (Klockhoff, 1961; Djupesland, 1961, 1962, 1967). Likewise, electrical stimulation of the ear canal can give rise to a contraction of the middle ear muscles (Pichler and Bornschein, 1957; Klockhoff and Andersson, 1959). The middle ear muscles are active during certain body movements (Carmel and Starr, 1963; Salomon and Starr, 1963) and during vocalization (Henson, 1965; Djupesland, 1967). Some people can contract their middle ear muscles voluntarily without producing any other obvious motor activity (Smith, 1943; Metz, 1951; Reger, 1960).

Several hypotheses have been advanced to describe the functional role of the middle ear muscles, especially with regard to the acoustic reflex. Comprehensive reviews have been given by Wever and Lawrence (1954), Jepsen (1963), Cancura (1970), Möller (1972) and Borg (1972b).

It has been suggested that the middle ear muscles (a) extend the dynamic range of the ear with regard to the intensity of sound (Borg, 1972d), (b) protect the inner ear against damage from exposure to high energy sound, (c) enhance ability for sound localization (Lawrence, 1965), (d) diminish the effect of middle ear resonance (Simmons, 1964; Wigand, 1965), and (e) regulate intracochlear fluid pressure (Tsukamoto, 1934) as well as middle ear air pressure (Politzer, 1861).

I. Reflex Arc

Politzer (1861) showed by electrical stimulation of the cranial nerves that the m. tensor tympani is innervated by the trigeminal nerve and the m. stapedius by the facial nerve. The reflex mechanism is localized in the lower brainstem according to Hammerschlag (1899, 1901) who studied the response of the m. tensor tympani in acute experiments with dogs. He also obtained evidence for the trapezoid body as a main link in the reflex pathway. Neuroanatomists have determined that the m. stapedius motoneurons are located in the medial part of the ipsilateral facial motor nucleus (Vraa-Jensen, 1942; Szentágothai, 1948) and the m. tensor tympani motoneurons in the ventrolateral part of the ipsilateral trigeminal motor nucleus (Szentágothai, 1949; Borg, 1973b).

The brainstem reflex mechanisms have recently been extensively analyzed in a study comprising physiologic recordings on rabbits with chronic brain lesions. Neuroanatomical methods for impregnation of degenerating neural structures were used (Borg, 1973b). Figure 1 summarizes the organization of the reflex arc based on these results. The brainstem of the rabbit is shown in three consecutive transverse sections. Nerve tracts transmitting reflex activity are shown as continuous lines and as dotted lines between sections. The m. stapedius reflex pathway is