the appearance of a beat note, or of a shift in loudness or pitch when an RF or an acoustic stimulus, or both stimuli, were presented. The remote panel also contained controls by which *O* could regulate the amplitude of acoustic stimuli, and the time interval (phase) between acoustic and RF pulses. The control knobs on the panel were reset randomly at different positions before each *O* was tested, to control for possible artifact borne of positional cueing.

A large steel drum that contained sterile seawater permitted individual *O*s to be tested while fully submerged or with the head at various levels above the water line.

2.2. *Observers.*

Both male and female observers, all normal adults, were observed for perceptual responsiveness to RF pulses and to acoustic stimuli. Before formal observations began, each *O* was tested for his or her high-frequency auditory limit (HFAL) of perception of sinusoidal sound waves when the initial test frequency of 1 kHz was ~ 40 dB above the threshold at that frequency. Audio signals at test frequencies above 1 kHz were initially presented at the same physical intensity and then were decreased until the signal was imperceptible.

2.3. *Acoustic environment.*

The background level of noise did not exceed 40 dB and was further reduced by plugging a subject's ears with paper stoppels or by attaching the sound-conducting tubes.

3. RESULTS

3.1. *Perceptibility of audio and RF sounds.*

Three *O*s had high-frequency auditory limits (HFALs) of sound-wave detection below 10 kHz. None of these *O*s could hear 10- to 30-μs RF pulses. Of 15 *O*s with HFALs above 10 kHz, only one could not perceive the RF pulses.

3.2. *Quality of RF sounds.*

All perceptive *O*s indicated that 10- to 30-μs wide pulses delivered at repetition rates that ranged from 1000 s^{-1} to 12,000 s^{-1} (at peak field intensities at the head in excess of 0.5 W cm^{-2}) resulted in a sound with a polytonal character. The sound seemed to have its origin in the head. As the pulse-repetition rate (PRR) of pulses of constant amplitude was increased from 1000 s^{-1} to 12,000 s^{-1}, the quality of the RF sound changed in a complex manner. Loudness fell sharply as PRRs increased from 6000 to 8000 pps, while the sound became more monotonal; however, the tonal quality in no case underwent mroe than three distinguishable tonal transitions. Subjects with HFALs below 15 kHz were unable to distinguish a 5000-pps signal from that at 10,000-pps. Subjects with more extended HFALs described the pitch (subjective frequency) at 5000 pps as higher than that at 10,000 pps.

3.3. *Difference thresholds.*

Small shifts of PRR approximating 5% were only detected in the region of 8000 pps. At lower PRRs, some subjects erred on 100% of test trials in attempts to specify the direction of change, which indicates that increasing PRRs were often perceived as decreasing in frequency. When widths of pulses of constant peak amplitude were gradually increased from 5 to 150 μs, a complex loudness function was observed. Loudness increased as widths increased from 5 to 50 μs, then diminished with further increase of widths from 70 to 100 μs, and then increased again with even longer pulse widths. Figures 1 and 2 present data on perceptual thresholds as a function of PRR and of pulse width.

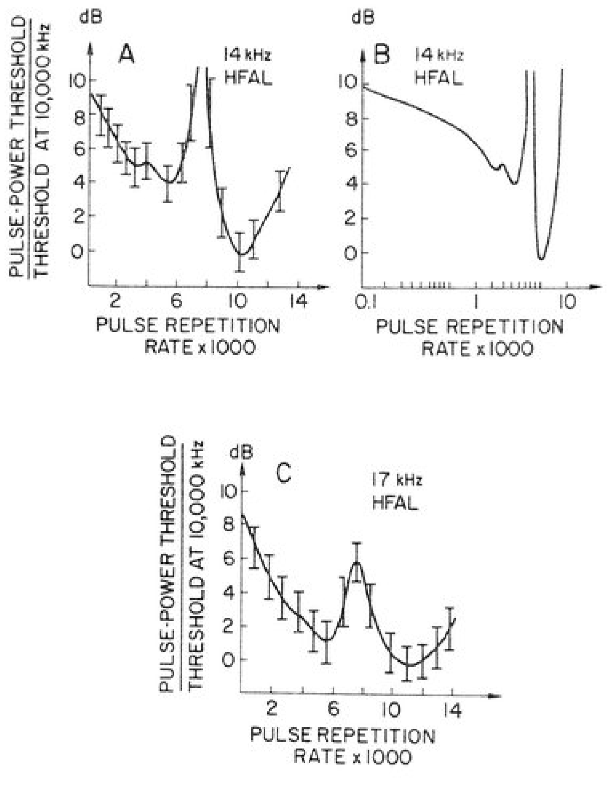

Fig. 1. Dependence of threshold of RF hearing on pulse-repetition rate (PPR). A: Curve of an observer with a high-frequency auditory limit (HFAL) of 14 kHz. B: Same as A, but logarithmically scaled. C: Curve of an observer with a HFAL of 17 kHz.