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EAR PROTECTION AND HEARING IN HIGH-INTENSITY IMPULSIVE NOISE

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High intensity impulsive noise differs from continuous noise firstly in the extremely high peak levels encountered and secondly in the very short duration of each impulse; to give an idea of the scale involved, the peak levels of the noise may in practice exceed 180 dB (ref. 2×10^{-5} N/m^2) with a duration as short as a few milliseconds. Lower peak levels and longer durations may also be encountered, and the number of impulses varies within wide limits. Damage risk criteria can be constructed relating peak level, duration and number of impulses under various conditions (1).

It is often found that some form of protection against impulsive noise is necessary if hearing is to be preserved, and the same types of ear defenders may be used as for continuous noise; it is generally assumed that the protection afforded is related to the pure-tone attenuation of the defenders. Unfortunately the problem of hearing low-level sounds, particularly speech, during the relatively quiet periods between impulses then becomes particularly acute, especially where good speech communication is vital for safety (2).

Where direct voice communication, rather than a trailing wire or magnetic loop system, is required, an ear defender with a much higher attenuation for high level than for low level sound may be used. Speech during the quiet periods is then heard relatively normally while the peaks of the high intensity impulse noise are removed. Little speech intelligibility is lost, since the impulse duration is short. The ERDEfender, developed by the Explosives Research and Development Establishment, uses this principle; here a basically normal pair of ear muffs is equipped with a microphone, peak-limiting amplifier and earphone built into each ear cup so that sounds of up to about 95 dB s.p.l. are heard almost normally but the amplifier limits transmission above this level.

While the ERDEfender is very efficient it is obviously rather expensive, and a little cumbersome. A much simpler means of achieving the same result, but with a slightly less sharp cut-off, is provided by the increase in impedance of a small orifice at high levels (3), where the originally laminar air flow becomes turbulent. With the great difference in peak level between high intensity impulsive noise and the wanted sounds such as speech, the more gradual increase in attenuation should not be too serious in practice.

Several types of ear defender with some form of small orifice have been designed, usually to obtain a particular frequency response. The orifice, together with the volume of air enclosed by the defender, forms a Helmholtz resonator, giving negligible attenuation at low frequencies and a fairly good attenuation above, usually, about 2 kHz. If the damping is small the attenuation at intermediate frequencies is negative. A similar effect is obtained with normal ear defenders with an accidentally introduced leak.

The object is to exclude the more harmful high frequencies while admitting low and intermediate frequencies to ease communication; one of the most ingenious designs is Zwislocki's Selectone - K plug (4) which incorporates a two stage acoustic filter. By itself this frequency-selective effect offers only a relatively small improvement over conventional defenders, but the existence of an amplitude-sensitive effect from the increase in impedance can also be demonstrated and offers a potentially greater improvement.

To take advantage of this effect a modified V.51R ear plug has been designed. The core of the plug was removed and replaced by a disc of 0.005 inch steel shim pierced by a 0.025 inch diameter orifice, thus giving a very much lower attenuation than for the original V.51R. The speech attenuation of the modified plug is of the order of 5 dB as against about 20 dB for the unmodified plug (2). The increase in attenuation first becomes apparent at about 110 dB (ref. 2×10^{-5} N/m^2) but does not become useful until much higher levels are reached. For impulses above 140 dB the increase is quite steady at the rate of about 1 dB per 2 dB increase in incident impulse, until the limit set by the attenuation of the unmodified plug is approached.

The modified plugs have been tested by several different methods and have been found to be very successful. They have been provisionally christened "Gundefenders" to emphasise their intended function, as with their negligible low-frequency attenuation they would evidently be of little use against most types of continuous noise.

Hearing loss from high intensity impulsive noise, like that due to continuous noise, can be eliminated if suitable ear protection is used; but this will become universal only if good communication is preserved. It appears that the types of defender described here offer the best means of combining easy communication and hearing protection.

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