Auto Noise-Reduction (ANR)

The front of the ANR Clansman boxes have a bright yellow (sometimes referred to as 'gold') faceplate fitted. They cannot be used with non-ANR headsets, because ANR headsets pick up a 24 volt power feed and use green PTT pressels which non-ANR ones do not. The non-ANR headsets use the earlier black PTT pressel switches, but can be operated using the green PTT pressel switches since they do not require a separate 24 volt power source to work. The black pressels cannot be used on the ANR headsets.

Slim ANR microphone (with wind muffler)

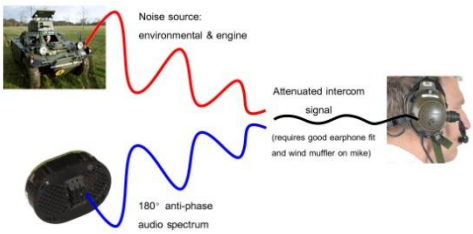
Rounded non-ANR microphone (wind muffler removed)

Clansman ANR headsets carry smaller, slimmer, electret microphones (NSN 5965-99-968-1304) on the boom (NSN 5965 99-513-8306) than the earlier non-ANR types. The wind mufflers are different also, being slimmer and shaped to the boom microphone. There are two types of Clansman ANR headsets: (1) the Dual Earpiece/earphone (one in each shell). This earpiece has two transducers, the front one is for normal audio, the one at the back of the earpiece is for the noise cancelling. (2) a miniature microphone transducer on the outer side of the headset (one in each shell).

In the Crewguard headset NSN 5965-99-614-7484 with the ANR dual Earpiece/earphone configuration, the ANR module is a self-contained unit marked with an arrow to ensure it fits a certain direction into the earpiece, enabling the ANR transducer sensor mike to pick up the background noise spectrum and sends out the anti-phase signal via the noise-cancelling boom microphone. This unit is held on stand-off pillars within each earphone. This ANR module holds the noise-cancelling electronics PCB and a sensor microphone which work through one of the two earphones in the earshell. The other earphone is a redundant unit for failsafe non-ANR comms as a conventional headset. There is an electret noise-cancelling boom microphone incorporating a voice-operated switch. The earshells house the voice-operated switch (VOS) and the talk-through (TTC) circuitry. The manually-operated TTC push-button being on the left-hand earshell, with bi-aural functionality from microphones on the outside of each earshell. When in use, the TTC cuts out the ANR function.

All auto-noise reduction (noise cancelling) systems have three components:

- A microphone that detects the sound spectrum that has entered the earshell cavity
- Electronics that processes this spectral signal and relays it to the anti-phase speaker
- The anti-phase speaker (ANR driver) that adds this reverse-phase spectrum into the earshell



Both earshells in a headset have these small detector microphones. Both detect the noise level . Above a threshold the inbuilt frequency filter is adjusted to give the anti-phase that attenuates the noise spectrum. Each earshell will provide ANR to left & right ears, depending on the instantaneous noise on the left or right of the head.

Sound is a pressure wave comprising alternating periods of compression and rarefaction. Auto noise-reduction works on the principle of the interference of waves, in this particular case by destructive interference. A noise-cancellation speaker emits a sound wave with the same amplitude but with **inverted phase** (anti-phase) to the original sound. In the aviation community, the phenomenon is called Active Noise Reduction. ANR *attenuates* unwanted sound; it does not mask unwanted noise, as is the case when a dentist uses music to mask the sound of their dentist's drill.

Passive noise reduction refers to noise reduction from the physical design and characteristics of the headset, whereas active (auto) noise reduction refers to the use of 180° anti-phase waves to attenuate or reduce unwanted noise. The Clansman headset uses analogue, rather than digital, noise cancellation. The profile of the cancelling signal must fall within the contour of the existing noise spectrum to get effective cancellation. At low levels of cancellation this is easy to achieve.

If the cancelling signal is either over-amplified or distorted in some way, the new signal will partially fall outside of the existing noise profile, and will thus be audible as new noise! Any feedback is heard as 'squealing'. This often occurs if an effective ear seal is not made, since a stable acoustic cavity in each ear dome is required for effective ANR.

Auto noise reduction improves the signal-to-noise ratio (SNR) heard in the earpieces. There is a lot of noise in the low frequencies, between 70 and 300 Hz. Noise levels decline in the higher frequencies particularly above 500 Hz. The hearing range for young people is from 20 Hz to 20 kHz, and reduced for the elderly to around 8 kHz.

Sounds are made up of fundamental frequencies, and harmonic multiples of these. It's the harmonics that give the sound its character. The speech of an adult male has a fundamental frequency from 85 to 180 Hz, and that of an adult female from 165 to 255 Hz. Frequencies between 500 and 4000 Hz are most important for speech processing. Typically this energy is concentrated in the vowel sounds. The consonants carry most of the meaning of speech in the 1 Khz to 6 Khz range but these are very weak (low energy) sounds. Consequently, the weak consonants are easily masked by noise, making it difficult to understand what's been said.

Loss of Consonants	Intelligibility for Adults
4% or less	Very Good
5%-8%	Good
9%-11%	Fair
12%-14%	Minimal
15% or more	Unintelligible

It doesn't take much masking before intelligibility is impaired, as the table above, from one study of adults with normal hearing shows. Even as little as a 10% loss in consonant sounds will substantially limit comprehension. The situation is worse for those with a degree of hearing loss or impairment.

Because of the masking effects low frequency noise has on speech, we have to turn the volume up to be able to partially hear normal voice frequencies. It is all too easy to deliver more than 110 db of communications audio directly to our ears through the headset speakers in an effort to better hear and understand what's being said! **Hearing loss: The real damage begins to develop with prolonged exposure to levels above 90 dB.**

Noise (noise in general) tends to be low frequency weighted when averaged over time. Wind noise is no different. Wind noise in helmets is measured in dB_A/dB(A) when it is studied. That is a measure weighted to human frequency sensitivity. But, even though noise tends to be lower frequency, noise induced hearing loss shows up first in the 4-6000 Hz range. This is because of the tonotopic representation of frequencies in the cochlea. The base of the cochlea, where all sounds enter, is the region most responsive to high frequencies. The low frequency receptive area is at the apex. So, all sounds pass over the cells responsible for high frequency detection even if they are low frequency sounds. Because of the nature of waveforms, the 4-6000 Hz area seems to be most susceptible. If you are exposed to high intensity, low frequency sounds over time, you will get a high frequency hearing loss. But, noise induced hearing loss does tend to show up first in the high frequency regions. Also, some listeners with sensorineural hearing loss may hear an elevated loudness at their hearing threshold.

When noise levels exceed 85 dB, they begin to have adverse effects on the speech comprehension. Studies have shown we need at least a 9 dB difference in the audio signal above the "ambient" noise levels in our headset to achieve 80% word recognition or better. An SNR of 12-15 dB allows a 90% recognition rate. To achieve full sentence intelligibility for listeners with normal hearing, the signal to noise ratio – the difference between the speech level and the sound level of the interfering noise – should be at least 15 dB_A.

ANR headsets are most effective at low frequencies. This means they are ideal for armoured vehicles. They are rather less effective for high frequencies such as wind noise. It is crucial to have an effective ear seal and the microphone fitted with a wind muffler placed very close to the mouth. By reducing low frequency noise exposure, they also permit audio signals and speech through the intercom **to be intelligible at reduced volume levels** whilst retaining a safe volume level (e.g. Portnuff et al, 2016). Please *do read* this warning given by the Army on the use of live intercom.

If speech sounds tinny and unnatural, it is because low frequency components of radio and intercom are cancelled along with the noise. Modern and more sophisticated ANR systems process the signal and noise separately, allowing for full reproduction of the original audio signal.