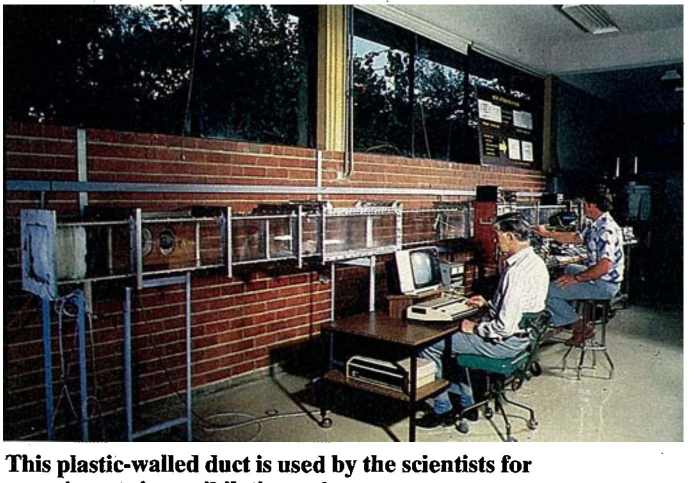
Annihilating noise with 'anti-noise'

Noise is but pressure fluctuations propagating through the air. The air condenses and rarifies in rapid alternation, and even when the fluctuations are small our ears respond with remarkable sensitivity. You can hear noise in which the pressure excesses and deficiencies are close to one-thousand-millionth of atmospheric pressure — the same pressure change you experience when your altitude alters by about a fiftieth of a millimetre!

Now the idea arises that if a loudspeaker could be made to produce a positive pressure wave whenever a negative one (rarefaction) came by, and a negative for a positive (condensation), then this 'anti-noise' would annihilate the noise.

Scientists at the CSIRO Division of Energy Technology are working on this intriguing idea, with the aim of developing techniques for reducing some types of troublesome noise in industry. In their laboratory they have reduced by three-quarters (a



This plastic-walled duct is used by the scientists for experiments in annihilating noise.

reduction of 16 decibels) random noise over a band width of 4·5 octaves (30–650 hertz) fed into an air duct. This is the best performance of an 'active noise attenuation' system to date.

The technique is suited to noise with plane wave fronts, as in a duct, and hence has potential for use in air-conditioning ducts, chimney stacks, and exhaust pipes. The leader of the group, Dr Andre Cabelli, is keen to try it out in industry.

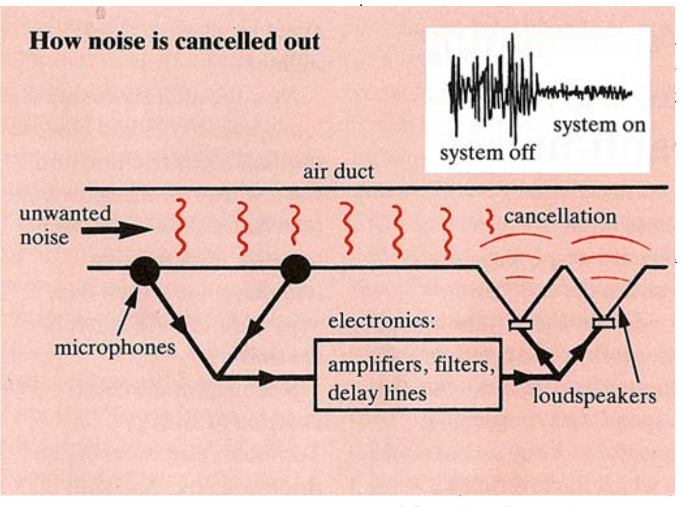
Active attenuation isn't a new idea, but making the idea work in practice has had to await recent developments in high-speed electronics. It's easy to cancel repetitive signals (tones) because the system can anticipate the next wave front. Random noise is difficult to deal with because the sound must be registered, analysed, and counteracted all in an instant.

The highest frequency the system can work at depends on the size and shape of the duct. Above a certain frequency the sound in the duct can adopt more complex patterns than the simple plane wave the attenuator was designed for. This factor limits the present highest operating frequency of the experimental system to 650 Hz. However, the same considerations make active attenuation particularly good in counteracting low-frequency noise, against which conventional silencers have the most trouble.

The system developed by the CSIRO workers — Dr Cabelli, Mr Frank LaFontaine, and Mr Ian Shepherd — uses microphones at one point in a duct and loudspeakers 2–5 m down the duct. The microphones are set up to respond only to sound propagating down the duct in one direction, and in essence the technique inverts the microphone's electrical signal, amplifies it, and sends it to the loudspeakers.

The time taken for the noise to travel from the microphones to the loudspeakers needs to be taken into account, and an electronic delay is inserted for this purpose.

Since errors in sensing and reproduction downgrade the attenuation, reproduction of the anti-noise must be of excellent quality. (To achieve 20 dB attenuation, the reproduced signal must match the noise to within 1 dB in amplitude and 5° in phase. Good-quality hi-fi speakers may show variations of 3 dB and 90°.) The problem was overcome by using a system called motional feedback, in which errors in the motion of the loudspeaker cone are electronically sensed and corrected.



The idea is to feed the loudspeakers with a signal exactly opposite to that picked up by the microphones. The oscilloscope traces show how well the system worked in one test.

The accompanying oscilloscope traces show the difference that switching on the system makes.

The researchers have found that the main limitation of the system results from turbulence in the flow of air down the duct. Attenuation fell to about 7 dB at a flow of 20 m per sec, from the 16 dB figure obtained with the air stationary. This is due to turbulent pressure fluctuations (not sound) being sensed by the microphones. The research team is working on ways of minimizing this disturbance.

Dr Cabelli feels that the technique has much to offer. He points out that, unlike conventional silencers, active attenuation doesn't hinder flow at all, and can be added on if trouble arises without upsetting a system's aerodynamics. Furthermore, the cost of an active attenuation system should be less than the conventional solution.

Andrew Bell

An experimental study of a broadband active attenuator for cancellation of random noise in ducts. R.F. LaFontaine and I.C. Shepherd. *Journal of Sound and Vibration*, 1983, **91**, 351–62.