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AN ACTIVE NOISE REDUCTION SYSTEM FOR AIRCREW HELMETS-FLIGHT TRIALS IN STRIKE AIRCRAFT

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INTRODUCTION

An active noise reduction system (ANR) has been developed for use in aircrew helmets, in which the acoustic noise field inside the ear defender is detected using a miniature microphone, and an antiphase signal is fed back to a communications telephone within the ear defender. The objectives for this development have been to improve speech intelligibility, and to reduce noise exposure.

Developed under contract to the Ministry of Defence (Procurement Executive), by the University of Southampton, the ANR system has been comprehensively tested in a series of laboaratory trials (1), followed by flight trials in a number of aircraft.

In order to eliminate user controls, an adaptive control facility has recently been added, which optimises the degree of noise cancellation to compensate for variations in helmet fit between wearers.

This paper presents the results of flight trials of the ANR system.

PRINCIPLES OF OPERATION

A block diagram of the system is shown in Figure 1. It comprises a negative feedback loop, incorporating an acoustic path between the telephone and microphone.

The design of the ANR-modified ear defender is based upon the existing ear defender shell and seal of the RAF Mk 4 aircrew helmet. The transfer function of the existing telephone of the helmet was not suitable for application to ANR, and a moving-coil device has been used instead. The microphone used in the feedback loop is a miniature electret type.

As the maximum gain of the feedback loop which can be applied before instability occurs depends upon the accuracy with which the feedback filter characteristics match the electroacoustic transfer function of the telephone-cavity-microphone combination, the system gain has to be set for each wearer, in order to obtain maximum potential from the system. Since the electroacoustic transfer function also varies between left and right ears for most wearers, two entirely independent ANR feedback loops are used, and therefore the setting-up procedure requires the setting of a gain control for each ear.

In order to eliminate this setting-up requirement, an adaptive gain control was developed for the ANR system, before extensive trials in single-seater strike aircraft were undertaken. This circuit monitors the noise levels at the ear, and continually adjusts the feedback loop gain to maintain a minimum noise condition in flight. In this way, not only are inter-wearer gain changes eliminated, but the small variations in helmet fit (and therefore in electro-acoustic transfer function), which occur with high - "g" in-flight manoeuvres, are also compensated for.

INITIAL FLIGHT TRIALS

The opportunity was taken to test the ANR system in a transport aircraft (a Hercules), enabling a number of subjects to take part simultaneously, and allowing University staff to experience the operation of the kit at first hand, in flight. During such flights, subjects made individual subjective assessments of the performance of the kits in terms of noise reduction, and effect upon communications, and in-muff noise recordings were made, using a Nagra IV SJ portable recorder. Subjects disconnected from the aircraft CCS for recordings, in order to obtain interference-free data. Figure 2 shows the mean ANR performance obtained in these flight trials, with plateau attenuation of 16-17dB, over a working range from below 50 Hz to 2.5 kHz.

MINIATURE ANR FLIGHT KITS

With the success of the early flight trials, a series of further trials were planned in strike aircraft, with RAF personnel as trial subjects. A prototype miniaturised kit was designed and built, some 150 x 100 x 25mm in size. The kit was battery powered, and intended to be worn in the knee pocket of a flying suit. Data outlets were provided for in-flight recordings on a miniature Nagra SN tape recorder. Nine sorties were flown with this kit by an RAF navigator at the Aeroplane and Armament Experimental Establishment, Boscombe Down, in Hawk, Harrier, Jaguar, Phantom and Tornado aircraft.

Flight conditions varied from high level handling, through low level navigation, to simulated combat. In addition to subjective observation and assessment by the navigator, a large number of in-flight recordings were made, and later analysed. The mean ANR performance, over all aircraft types, for the trials was a plateau of 14-15 dB active attenuation with a working range of 50 Hz to 2.5 kHz. Subjective assessment noted a substantial improvement in noise level at the ear.

Following this, a quantity of miniature kits were built for more extensive user-evaluation by RAF aircrew. The kits were again battery-powered and small enough to fit in a flying suit pocket. Most of the kits incorporated an adaptive gain control facility, as described earlier.

At the time of writing, these trials are in progress, and final results cannot be quoted. However, initial response from the aircrew corroborates the subjective assessments of earlier subjects, and the recorded data show ANR performances similar to those quoted above, attenuations of up to 20 dB being measured. Figure 3 illustrates a typical performance.

CONCLUSIONS

The viability of the ANR system has been proved during laboratory and flight trials in a range of aircraft. Continual development of the electroacoustical design of the system has allowed a steady improvement in performance to be made, such that the current design provides some 15-20 dB active attenuation over a working range from below 50 Hz to beyond 2 kHz. The effect of this additional attenuation is to reduce in-flight noise levels at aircrew members ears by some 15-20 dB(A), depending upon aircraft type.

The system could be incorporated into aircraft communications systems at the design stage, or could be used in man-pack form in the short term. It is intended to investigate the application of the system to rotary-wing aircraft in the near future.

REFERENCE

1. P.D. WHEELER et al, Internoise, San Francisco 1978.

ACKNOWLEDGEMENTS

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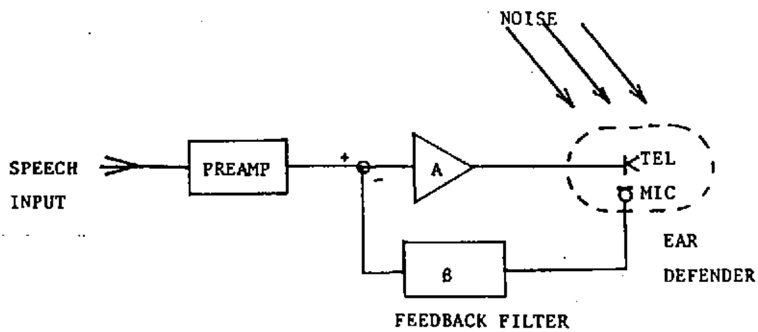

FIGURE 1 - ANR SYSTEM BLOCK DIAGRAM

AN ACTIVE NOISE REDUCTION SYSTEM FOR AIRCREW HELMETS-FLIGHT TRIALS IN STRIKE AIRCRAFT

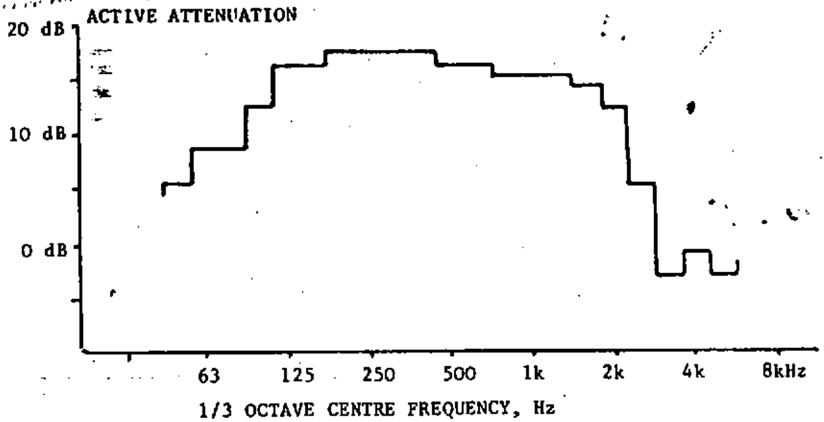

FIGURE 2 - MEAN ACTIVE ATTENUATION IN HERCULES TRIALS

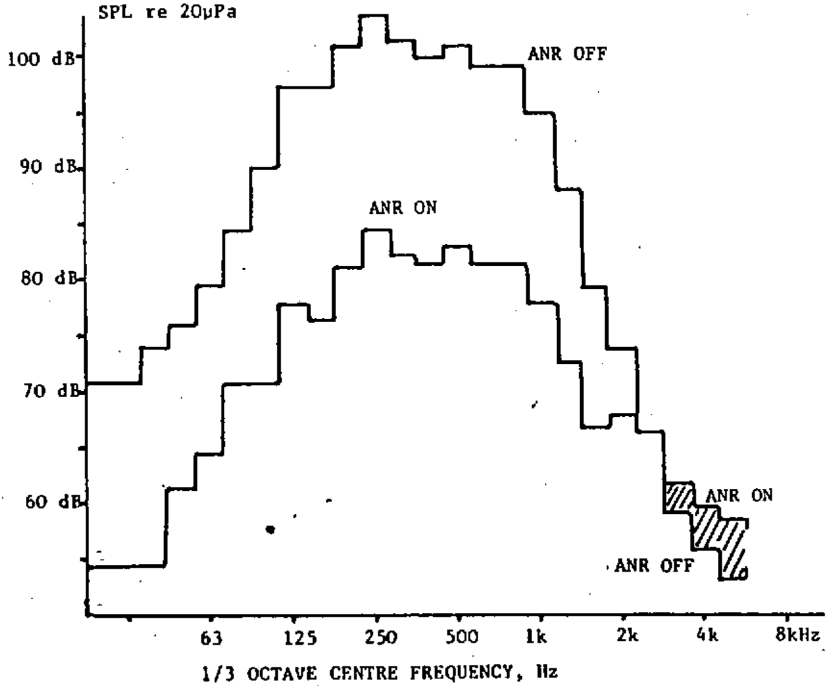

FIGURE 3 - SPL AT CREWMANS EAR IN BUCCANEER AIRCRAFT