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N92-32964

A LIGHTWEIGHT LOUDSPEAKER FOR AIRCRAFT COMMUNICATIONS AND ACTIVE NOISE CONTROL

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Presented to **The 4th NASA/SAE/DLR Aircraft Interior Noise Workshop**
19 and 20 May 1992
Graf Zeppelin Haus
Friedrichshafen, Germany

Summary

A series of new, lightweight loudspeakers for use on commercial aircraft has been developed. The loudspeakers use NdFeB magnets and aluminum alloy frames to reduce the weight. In the cases where high voltage transmission lines are employed, the transformers used on conventional loudspeakers are replaced by high impedance voice coils of 1000Ω to 2000Ω DC resistance to lower the weight still further. The lightweight cabin loudspeakers are 15cm in diameter and weigh only 39% as much as conventional designs without transformers and only 27% as much as conventional designs with transformers. A 10cm diameter loudspeaker for use in avionics equipment weighs only 70g. The lightweight loudspeakers can replace current designs and meet all U.S. aircraft requirements. These loudspeakers are now being produced and installed in commercial aircraft.

The NdFeB magnet is virtually encapsulated by steel in the new speaker designs. As a result, the stray magnetic fields are extremely low and cannot be detected by standard means beyond about 25cm. This means that they will not cause magnetic interference with equipment on board. Since the loudspeakers also have reduced height and smaller volume, they may be used with tightly packed avionics packages.

The field intensity of the magnet may be increased 15% by adding a small "bucking" magnet of inexpensive ferrite to the design. This increases the weight by only 6% or 7%. If an NdFeB bucking magnet is used, the weight penalty is only about 0.6% to 0.8% for a 15% gain in magnetic field strength. In addition, the loudspeakers were tested for back emf. The back emf was found to be low and will produce no electrical problems.

Active noise reduction using internal loudspeakers was demonstrated to be effective in aircraft in 1983. A weight, space, and cost efficient method for creating the active sound attenuating fields is to use the existing cabin loudspeakers for both communications and noise attenuation. To accomplish this the loudspeakers must produce a speech to noise ratio of +4dB or +5dB in a noise field of approximately 75dB SIL. At the same time, the loudspeakers must be capable of several decibels of "headroom" to accommodate the active noise reduction signal without speech distortion. The lightweight loudspeakers are capable of achieving this or can easily be made capable of doing so. However, the dual usage of the cabin loudspeakers would raise their duty cycle from 4% or 5% to 100%. This would require some additional loudspeaker design considerations. An overall system design of the combined communication and active noise control sub-systems to provide proper equalization and amplification of both functions would also be required.

TABLE I

	CONVENTIONAL	LIGHT WEIGHT	WEIGHT RATIO: LIGHT WEIGHT / CONVENTIONAL
15 cm Diameter Cabin Loudspeaker With Transformer	686 g	185 g with high impedance voice coil and resistor network	0.27
15 cm Diameter Cabin Loudspeaker Without Transformer	387 g	151 g	0.39
10 cm Diameter Cockpit/ Avionic Loudspeaker	-------	70 g	------

Figure 1. Conventional 15cm Diameter Loudspeaker (left) and Lightweight Loudspeaker (right).

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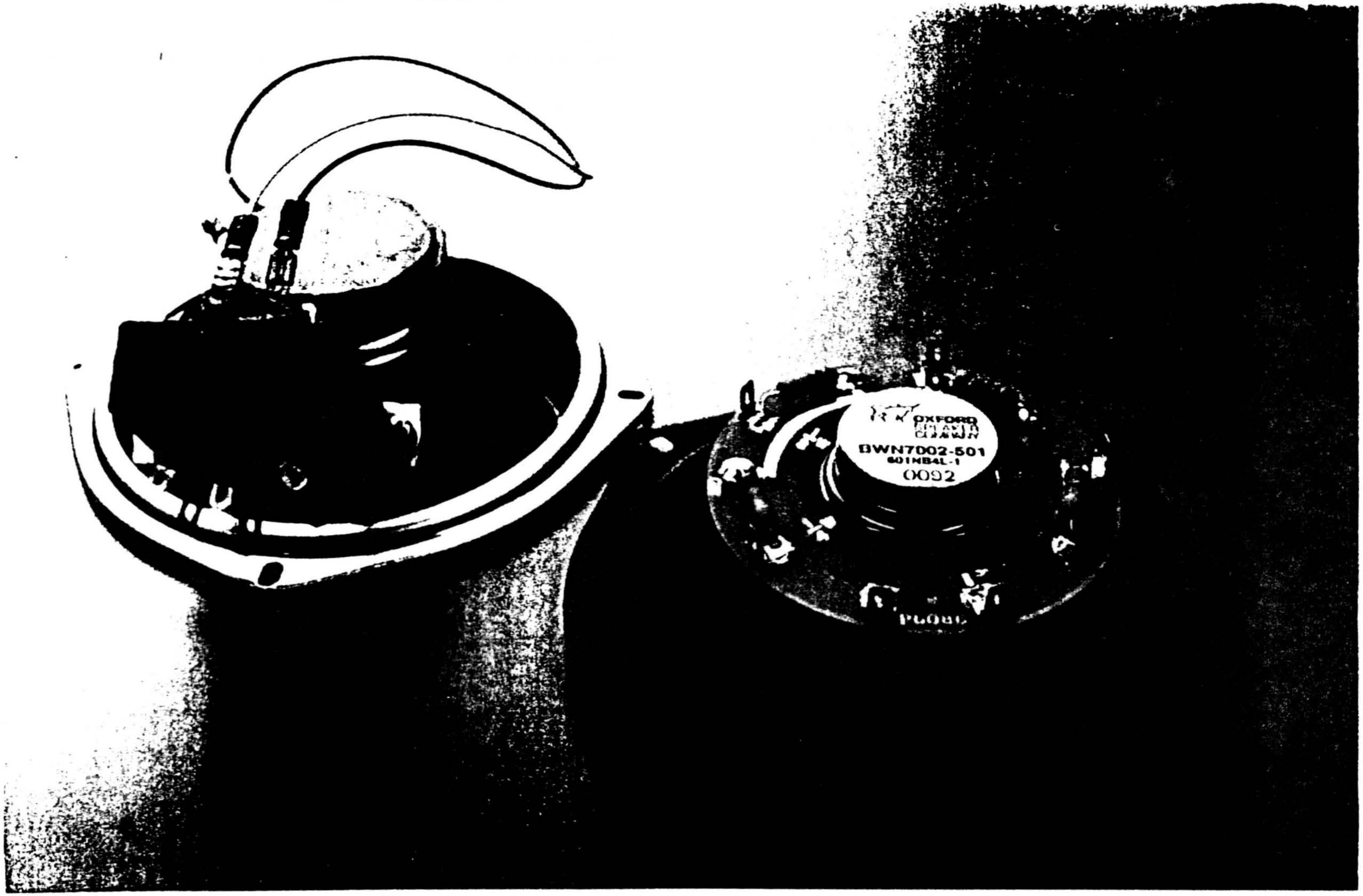

Figure 2. Conventional 15cm Loudspeaker with Transformer (left) and Lightweight Loudspeaker with High Impedance Voice Coil and Resistor Network (right).

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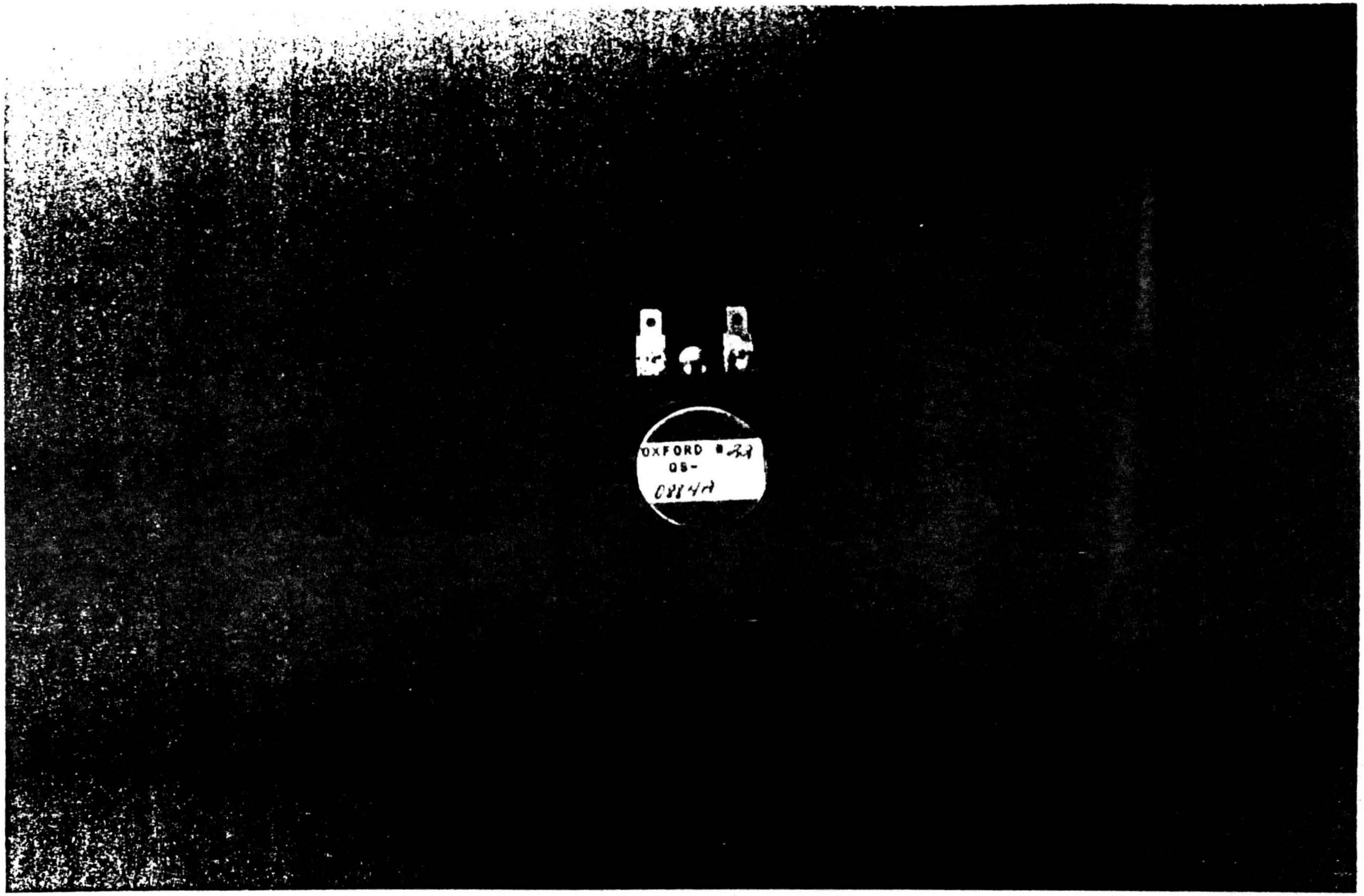

Figure 3. Lightweight 10cm Diameter Loudspeaker.

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Figure 4. BACK emf TEST CONFIGURATION

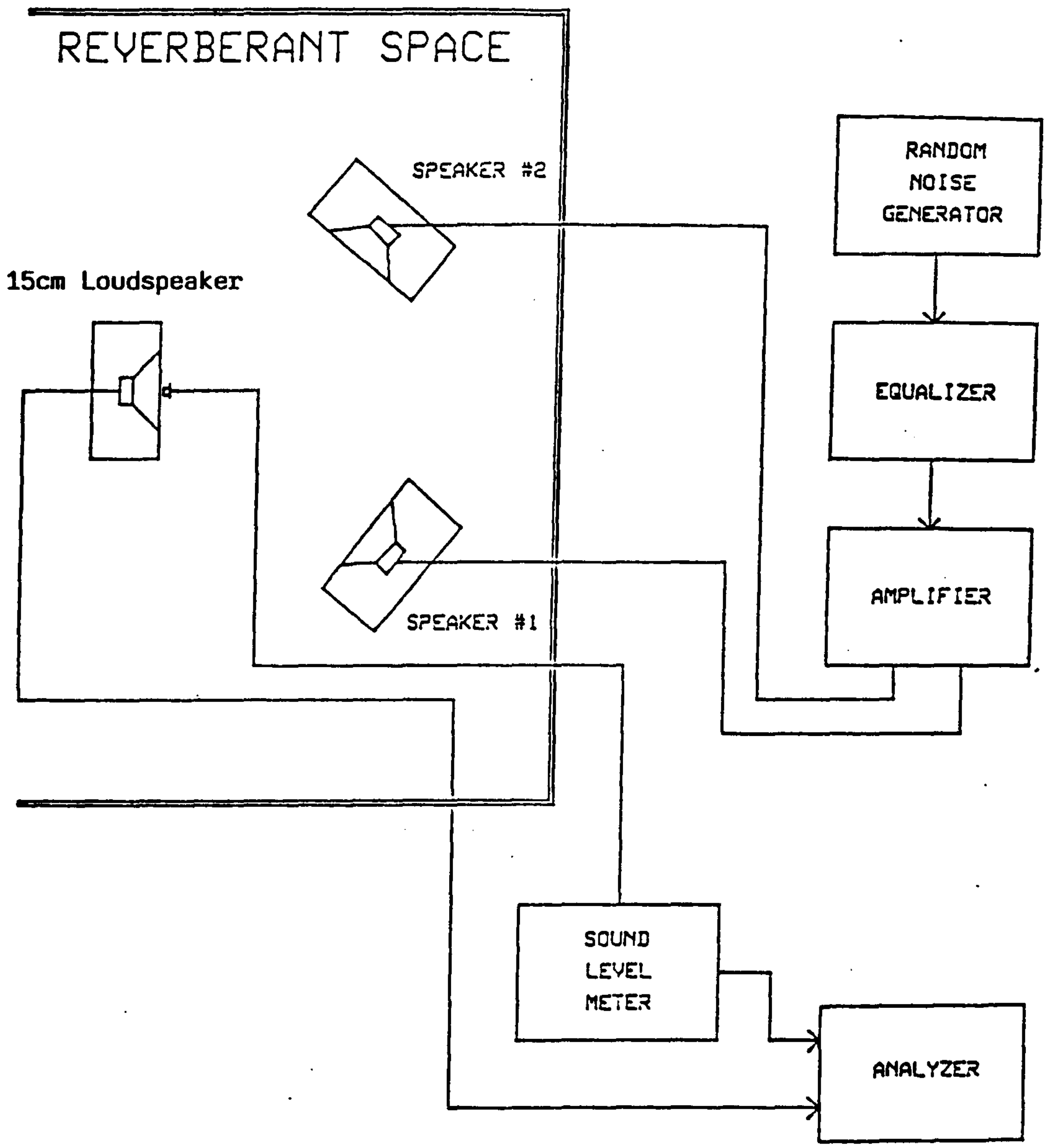


Figure 5. Back emf of 15cm Lightweight Loudspeaker to Steady State Excitation and Electrical Noise Floor 4 Watt Connection. Data to 12.8 kHz

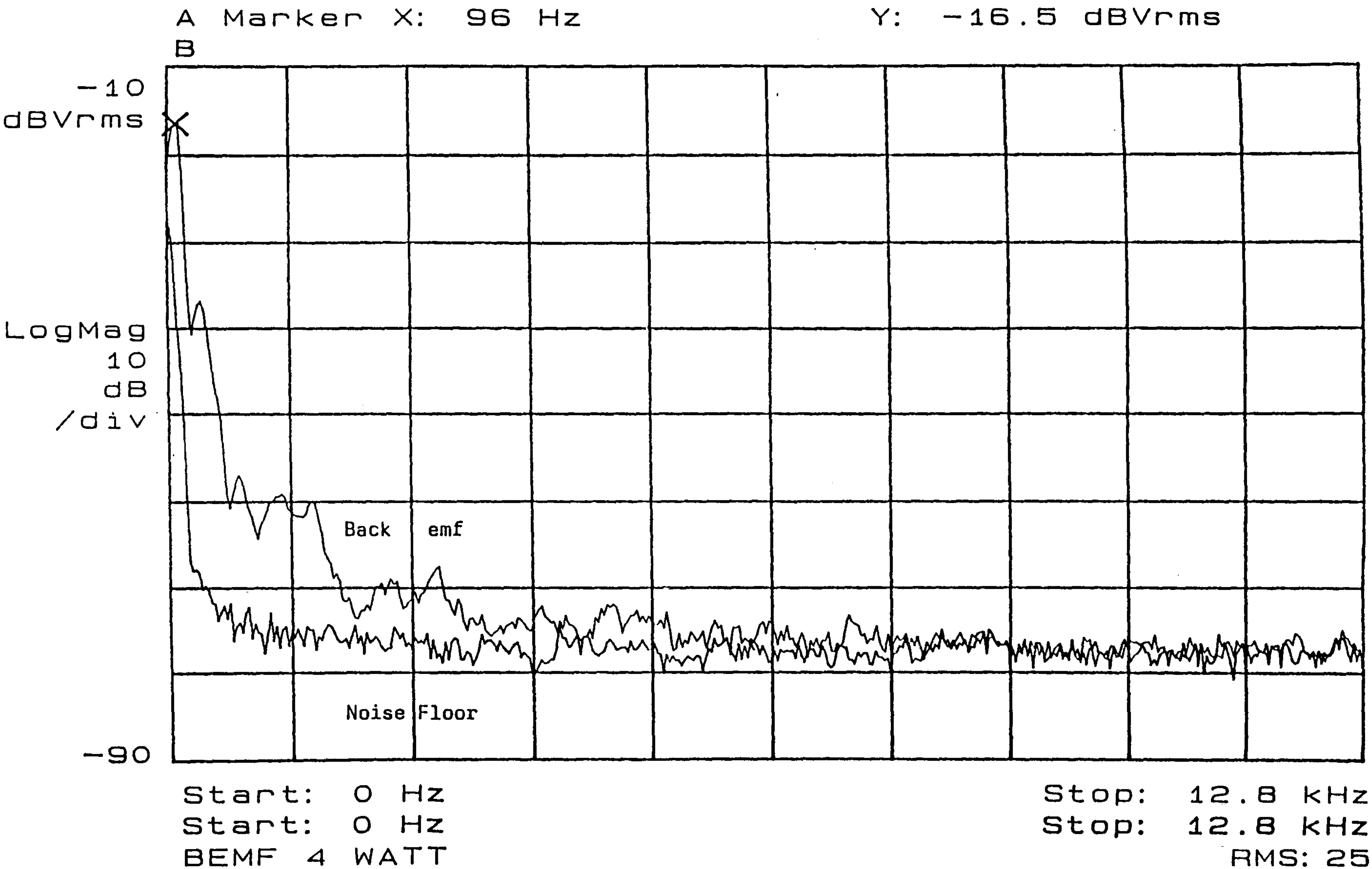
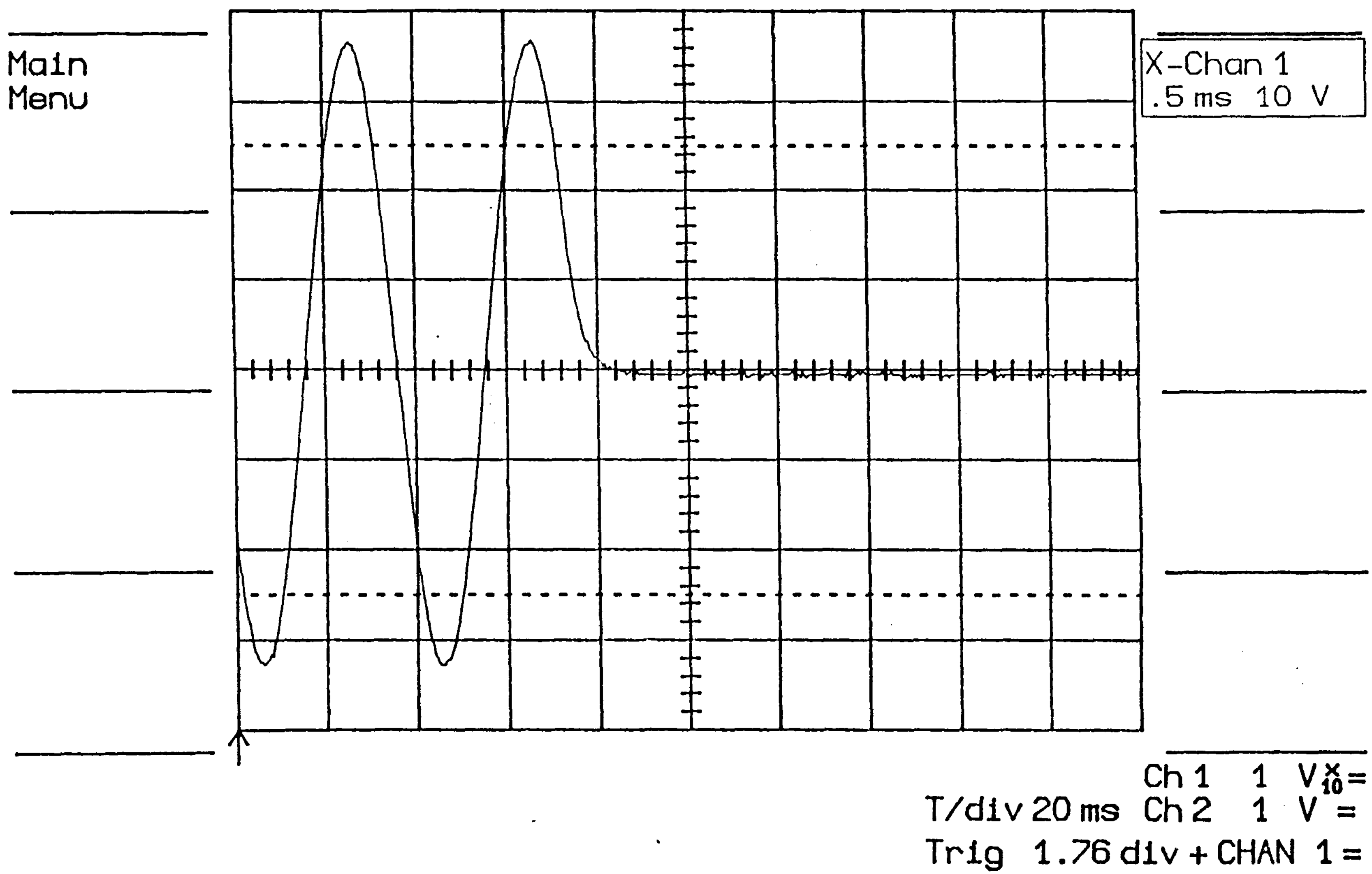


Figure 6. Transient Electrical Response of 15cm Lightweight Loudspeaker 4W Connection. 70 Volt Excitation.



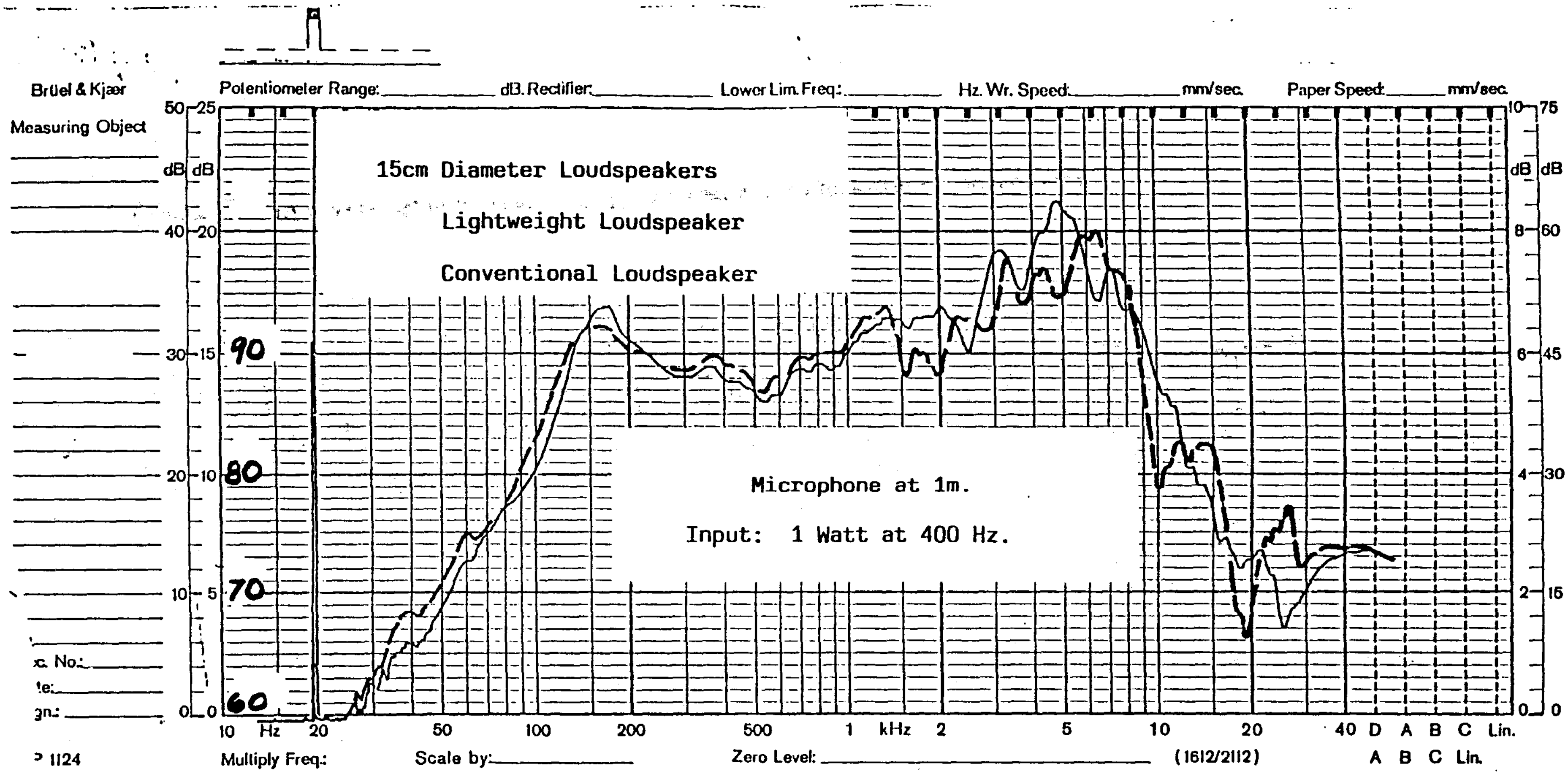


Figure 7. Comparison of the Frequency Response of a 15cm Diameter Lightweight Loudspeaker and a Conventional Loudspeaker.

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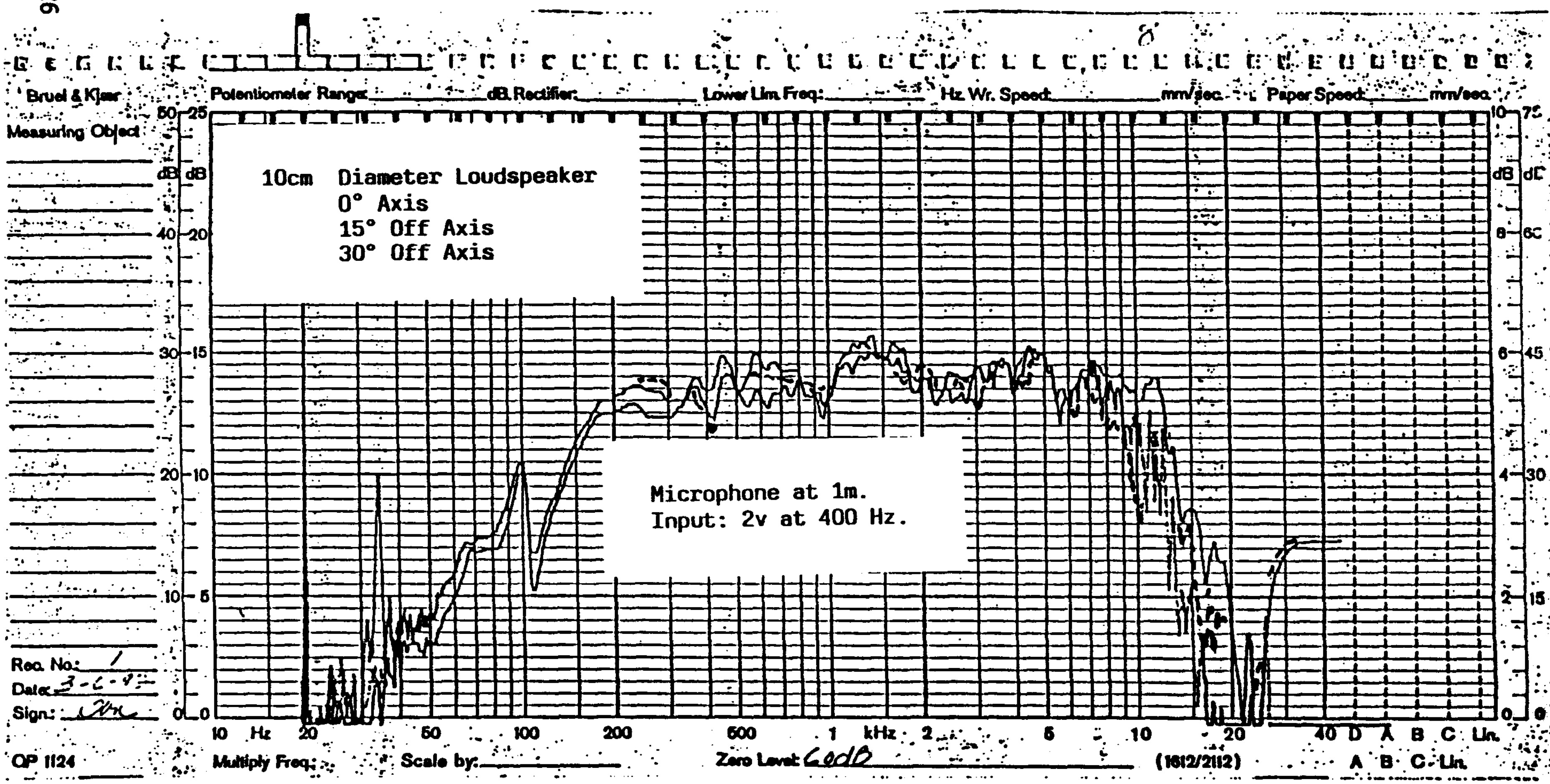

Figure 8. Off Axis Measurements of 10cm Diameter Lightweight Loudspeaker.

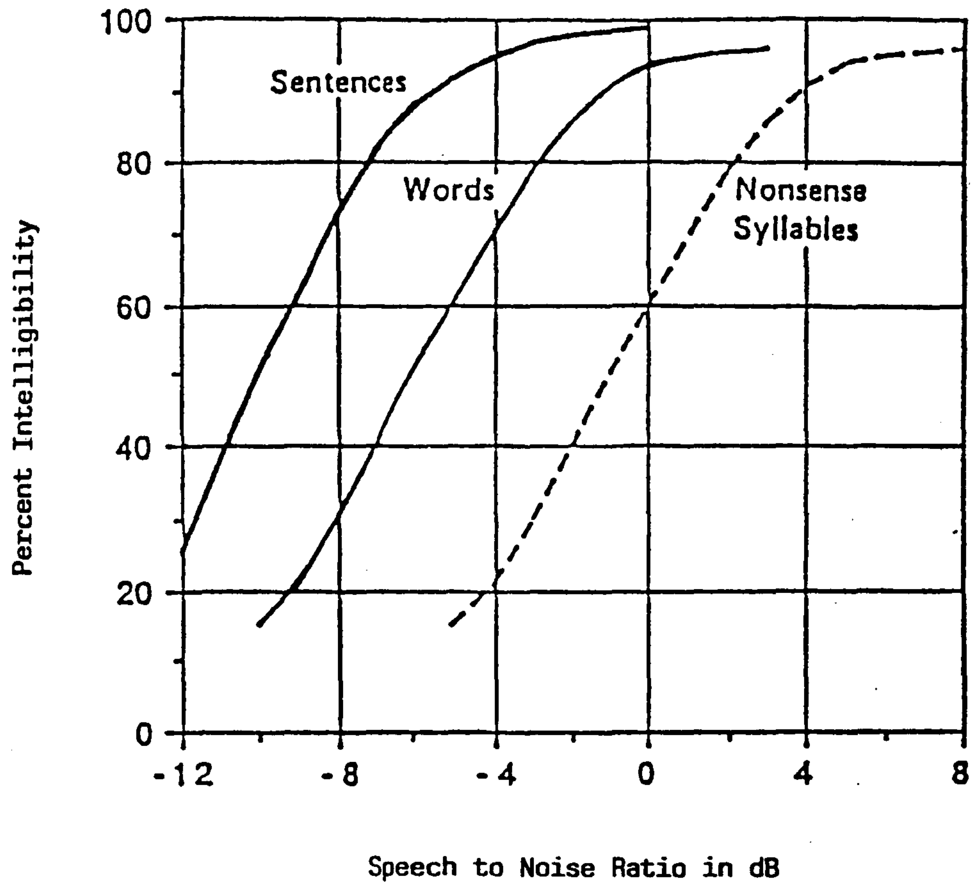

Figure 9. Intelligibility of Different Spoken Material in a Noisy Environment.