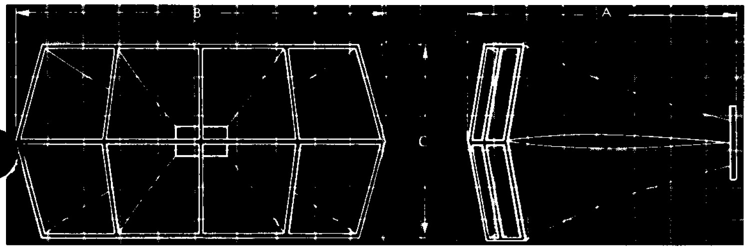

ALTEC ENGINEERING NOTES

TECHNICAL LETTER NO. 227A

NOTES ON NOISE MASKING/SPEECH PRIVACY SYSTEMS

By

Richard Forbes and John Eargle

INTRODUCTION

With the growing use of noise-masking systems on a nationwide basis – in modern office buildings, in apartment complexes, and particularly in new Federal Government construction – some basic information about the concepts, applications, equipment and techniques of these systems will be useful to the Engineering Sound Contractor. Recent work by a number of acoustic consulting firms has evolved certain basic criteria, terminology, and definitions used in the successful design and completion of noise-masking systems. A brief discussion of some of these items is necessary for a basic understanding of the applications and techniques of noise masking.

Noise masking is used for two basic purposes – first, to achieve a certain degree of speech privacy, which might be either *normal* privacy or *confidential* privacy between two adjacent defined spaces; second, to unobtrusively mask (block out) other *unwanted* noises. In a new *open space* office building, for example, where offices or desks might be separated only by partitions, or where there might be a total lack of partitions, noise masking would likely be required to ensure that a conversation at one desk does not interfere with conversation at an adjacent desk, or is not overhead at an adjacent desk. As another example, in an office building or apartment complex built near a freeway, noise masking might be useful in **blocking out** unwanted traffic noises.

Noise masking, very simply, is a technique which reduces the signal-to-noise ratio between unwanted sounds, speech or otherwise (signal), and the background ambience (noise), to a level approaching zero. This is done by introducing a controlled, more acceptable background noise, by use of loudspeakers, and raising it to a level approximately equal to the level of the unwanted noise (signal) at a specified distance from its source. The masking noise introduced is broadband random noise, and is equalized to compensate for varying attenuation rates in the space.

A basic layout for a typical noise-masking system is shown in Figure 1. Talker A radiates sound that hits an absorptive partition and is thus attenuated in reaching listener B. Some sound from A reaches B by reflection from the absorptive-type suspended ceiling as well as by diffraction around the partition. The result at B is a sound pressure level low enough that it can be effectively masked by a suitably shaped noise signal *via* the loudspeakers in the plenum. Obviously, if the sound reaching B from A were not sufficiently

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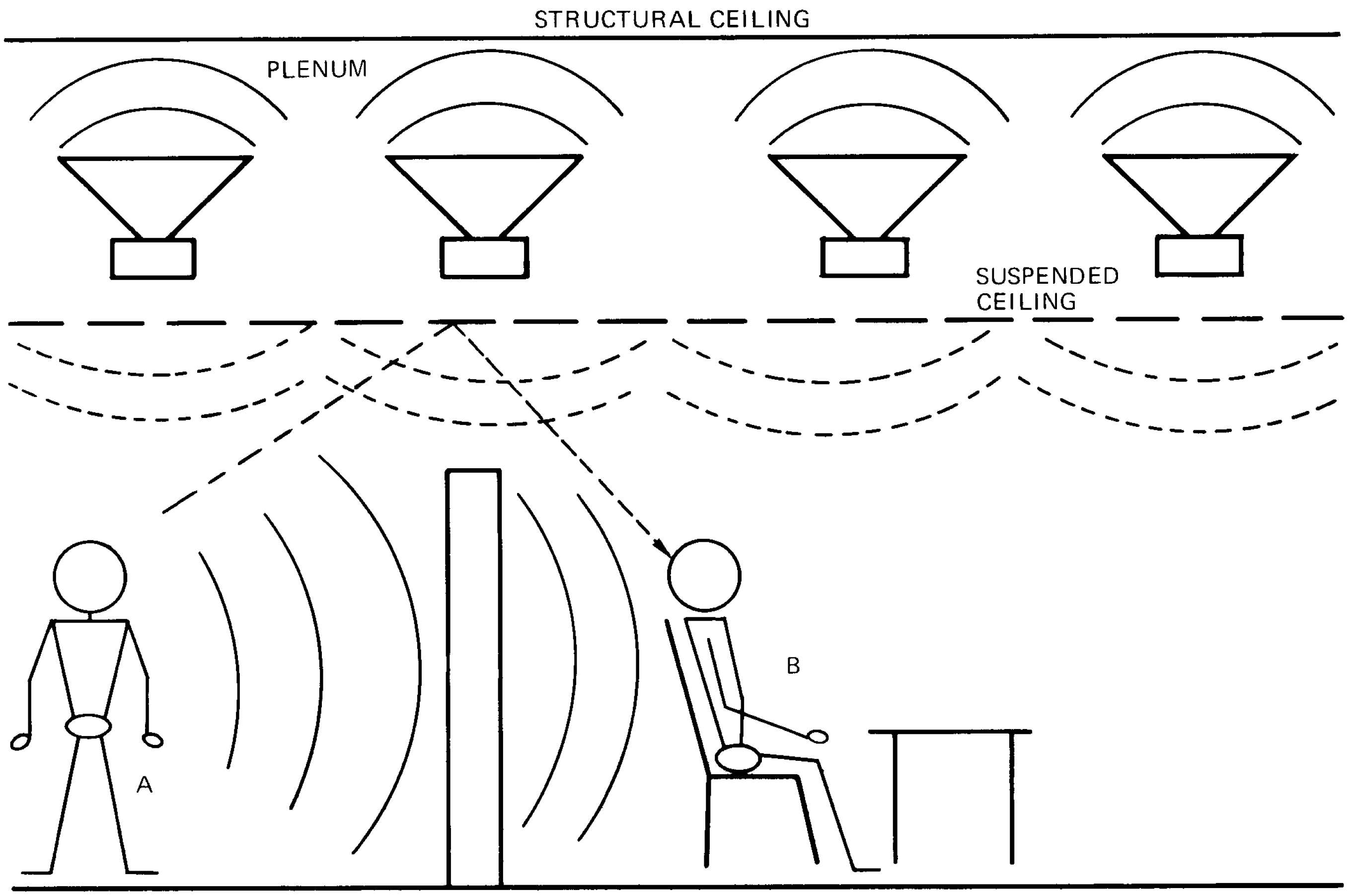

Figure 1. Basic Layout for Typical Noise-Masking System

low in level, the noise level required to mask it would in itself be obtrusive and unsatisfactory to people in the office area. If the attenuation, as a function of distance, is sufficient between A and B, the use of partitions may be eliminated and the same result achieved.

The equipment used in a noise-masking system is already well known to Altec Engineering Sound Contractors, and is available in the Altec Industrial/Professional Sound Products line. Basically, a system will consist of a noise generator (such as the 8080A), an equalizer (such as the 9860A), power amplifiers, and a high-density distributed loudspeaker system. The system may also include a mixer-preamplifier, depending on whether or not it will be used for some additional function. Instructions for field modification of the 9860A to accept an 8080A directly are found at the end of this Technical Letter.

The major difference between a noise-masking system and a *normal* music-distribution or voice-paging system is in the placement of the loudspeakers. The success of a noise-masking system depends on appropriate acoustic treatment of the space, including the use of a suspended acoustical tile ceiling which results in a plenum above the ceiling. In these systems, it is necessary to make the *noise sound field* as diffuse as possible, thus the plenum becomes an ideal location for the loudspeaker assemblies. A typical installation might include Altec 405-8G 4-inch loudspeakers, in 200-cubic-inch enclosures, mounted directly above the suspended ceiling in a high-density pattern and aimed upwards (see Figures 2 and 3).

Broadly speaking, the rectangular density pattern of Figure 3 is based on a reflected signal from the structural ceiling, resulting in 50% overlap of the signal from adjacent loudspeakers at the listener's ears.

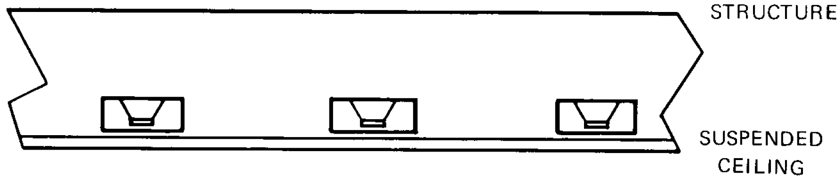

Figure 2. Cross Section of a Typical Plenum Loudspeaker Installation

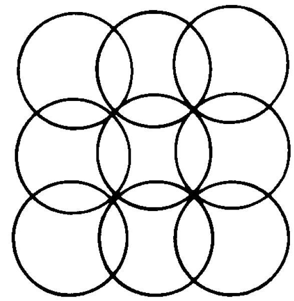

Figure 3. High-Density Speaker Layout

A detail of this is shown in Figure 4. This is roughly equal to conventional mounting in a rectangular pattern with minimal overlap.

If the system is to be used for music distribution or voice paging as well as for noise masking, conventional mounting of the loudspeakers will be necessary. In this case an even higher density will be required (see Figure 5), since maximum diffusion (±2 dB coverage at seated ear level) is desirable, if not essential. A 90° dispersion angle may be assumed for the 405-8G in a 200-cubic-inch enclosure within the frequency spectrum used in noise masking (Reference Technical Letter No. 221).

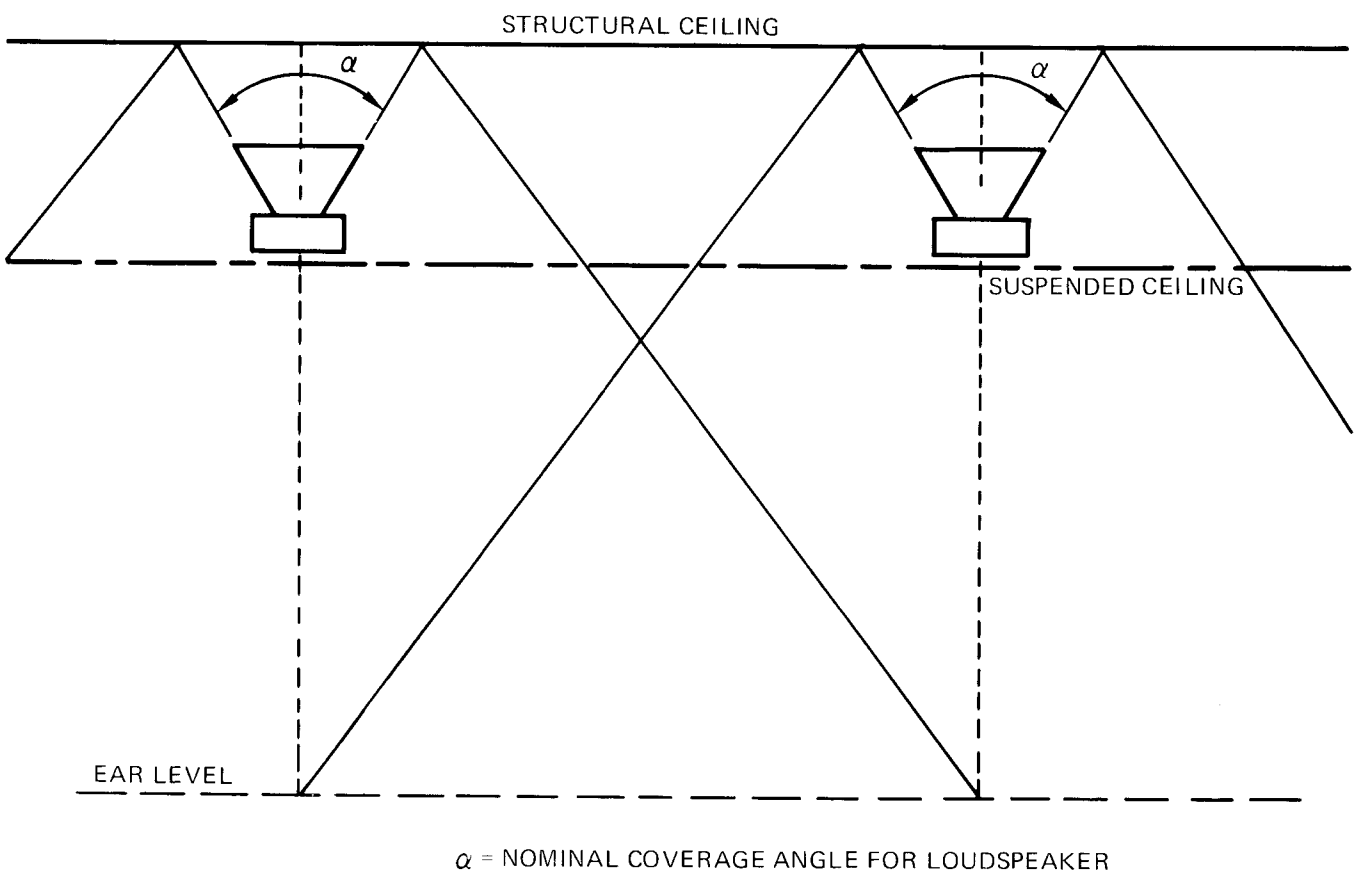

Figure 4. Overlap of Speaker Distribution Pattern

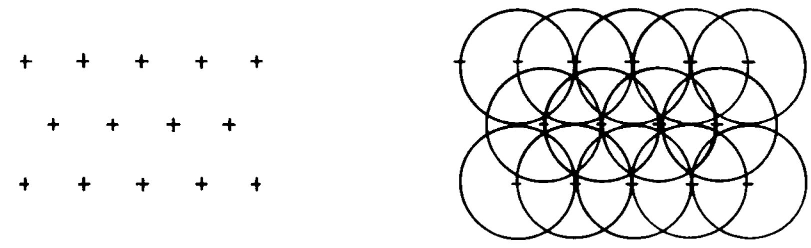

Figure 5. Crisscross Overlap

POWER CONSIDERATIONS

Random noise signals require a high *crest factor.* An amplifier should be capable of delivering 10 times its average power for peak requirements; thus, if an amplifier has a maximum output of 100 watts, it could be expected to deliver 10 watts on a continuous basis into a noise-masking array. The normal allocation is 1 watt per loudspeaker, although the *average* power per speaker may be even less than 0.1 watt. The actual required wattage would be determined by the noise level required as well as by the sound-transmission loss through the suspended ceiling material. It is very important that noise levels be accurately maintained for proper masking. There should be no controls, other than on-off, available to the client. All of the Altec components specified for noise-masking work are quite stable; however, when there are a number of zones, each on a separate amplifier, a switchable meter should be made available to local maintenance personnel for monitoring power output levels. There should be appropriate padding in each input to the switch to result in a single reference reading on the meter. This is shown in Figure 6.

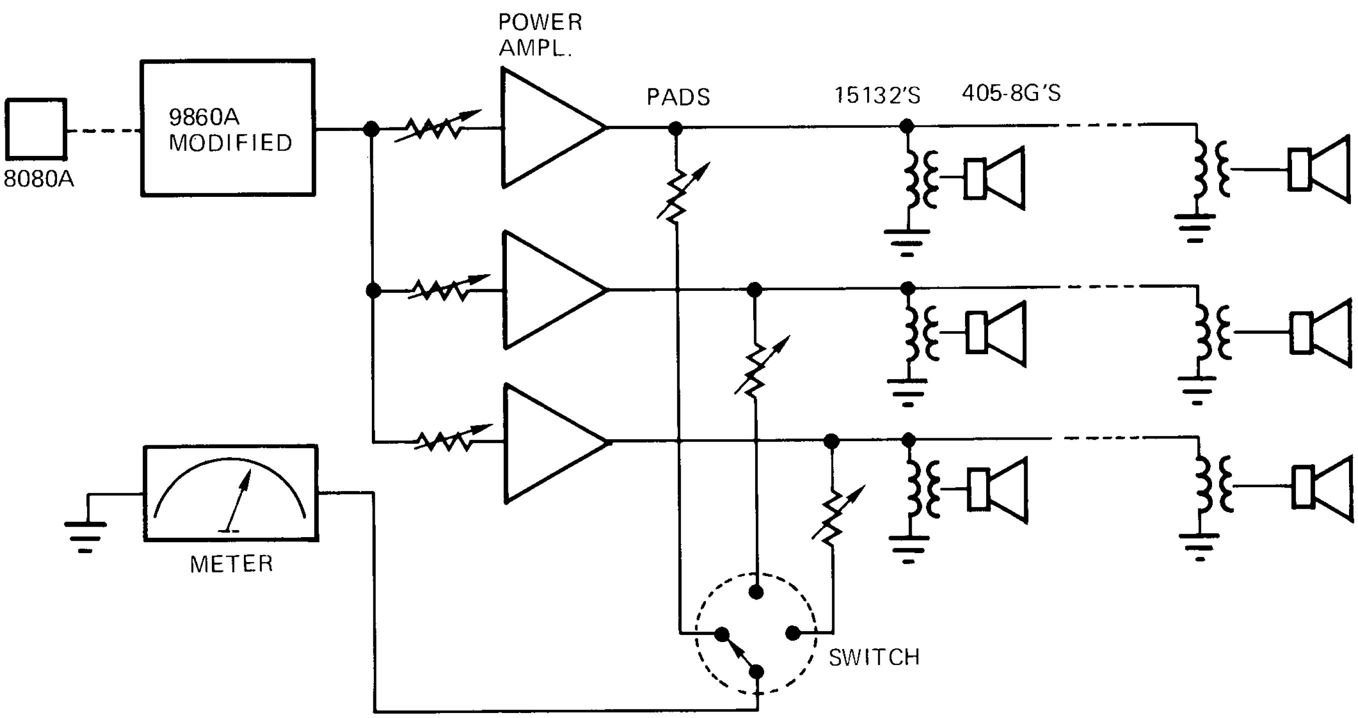

Figure 6. Block Diagram of Multiple-Zone System

ACHIEVING ACCEPTABLE NOISE-MASKING LEVELS

Subjective testing has determined that for a noise-masking system to be successful, T_{60} in the space should be no more than 0.7 second at 500 Hz, and no more than 0.5 second at 2000 Hz. Additionally, the ambient noise level in the space should be held, if possible, to a Noise Criteria (NC) curve of NC_{35} (see Figure 7), or to a maximum of NC_{40}. For every 2 dB increase in ambient noise over NC_{40}, the average talker will subconsciously raise his voice level 1 dB, requiring a corresponding increase in the masking noise to a level which may be objectionable to most people exposed to it. Further subjective testing has shown that most people exposed to masking noise at a level approximating NC_{30} will not be conscious of it. NC_{35} has been judged nonobjectionable, although some people become aware of masking noise at this level. All of those tested were aware of noise generated at NC_{40}, and although some considered this objectionable, most people seem capable of *living with* this level. NC_{40}, however, seems to be the upper limit of noise level for the *practical* use of masking systems.

Figure 8 shows an alternate curve widely used for masking. If noise is shaped according to this curve, it will read about 56.5 dB SPL on the linear ("C") scale of a sound level meter and about 46.5 dB SPL on the "A" scale. In general, the final spectrum is shaped by ear, but the deviations from the curves shown in this Technical Letter would be only slight.

A number of octave-band equalizers have been used in masking work, but we feel these devices do not provide enough flexibility in fine tailoring of the noise spectrum. The 9860A is recommended because it

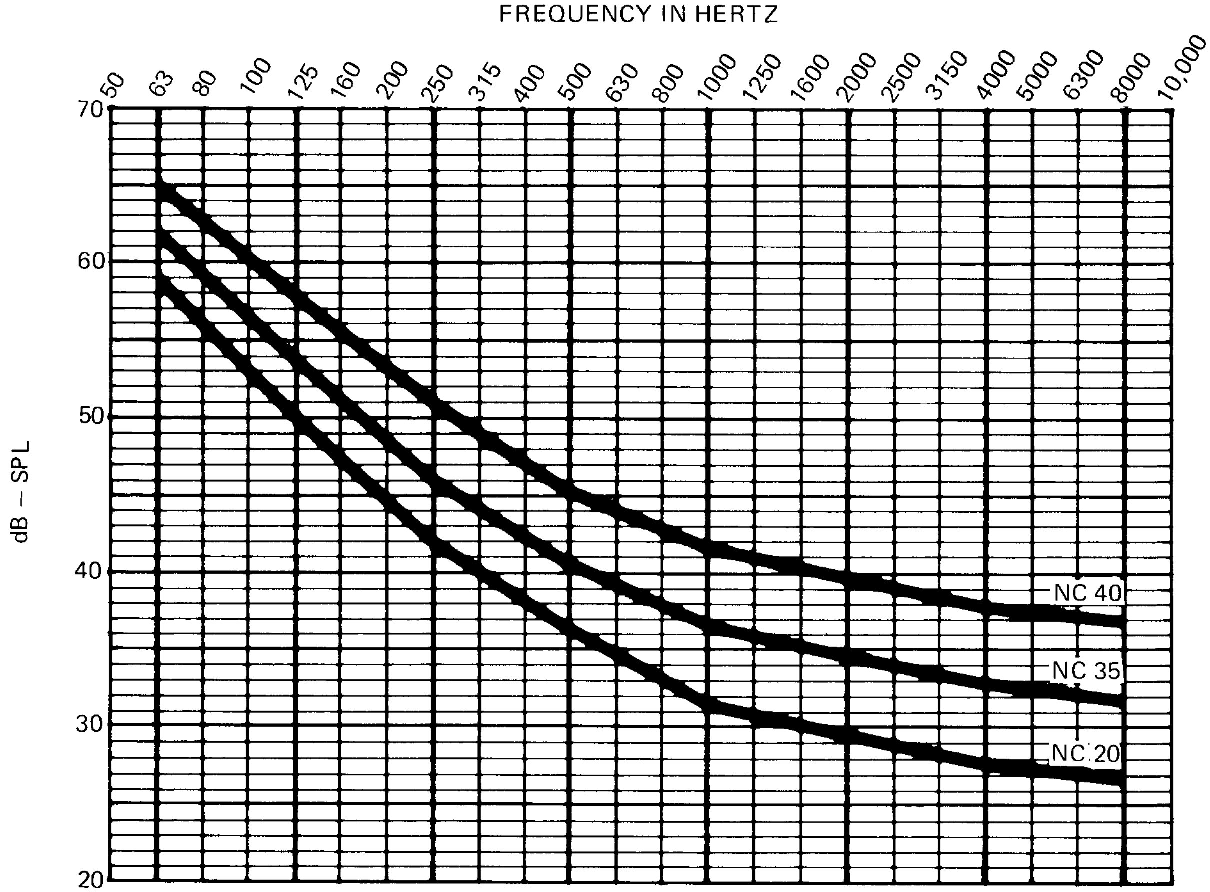

Figure 7. NC Levels *

*See **NOTE** page 8.

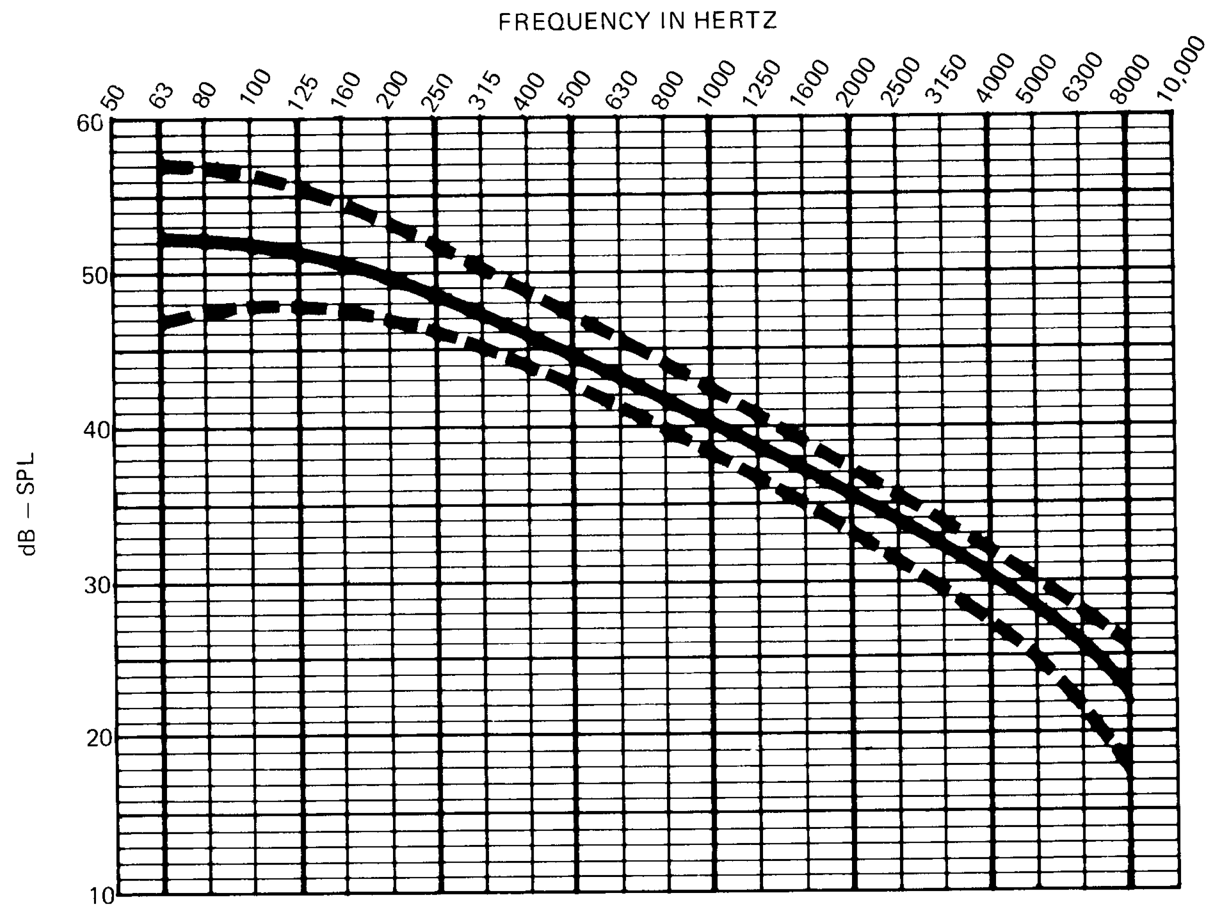

Figure 8. Alternate Noise-Masking Curve *

allows a desired contour to be achieved within a tolerance of ±1.5 dB. The *front end* investment, in any event, is a small portion of the total cost of the system. The use of a lower-priced equalizer will have little effect on the total price of the system, and it will very likely limit the performance of the system.

Another useful family of curves are the Noise Isolation Class (NIC) curves. These are standard attenuation or noise-reduction curves, which are normally achieved through the proper use of acoustic materials and methods and which complement the NC curves. Figure 9 is a typical NIC curve.

Achievement of the desired NIC in a space will involve a number of factors:

- The absorption coefficient of boundary surface materials, particularly the ceiling
- The attenuation, with respect to distance, between two adjacent defined spaces or zones
- The use of acoustic barriers, or sound screens, between zones.

For successful noise masking, interzone attenuation (A_I) should be a minimum of NIC_{20} (see Figure 9). In a *normal* space, with a 9-foot ceiling height, an adequate A_I will usually mean an interzone distance of not less than 9-12 feet and/or the use of sound screens. The sound screens should have a transmission loss of *not less than 10 dB* between 400 and 2000 Hz, should exhibit an average absorption coefficient ($\bar{a}$) of at least 0.70 within those frequencies, should extend to the floor, and should be not less than 5 feet high for *normal privacy* and 7 feet high for *confidential privacy.*

*See **NOTE** page 8.

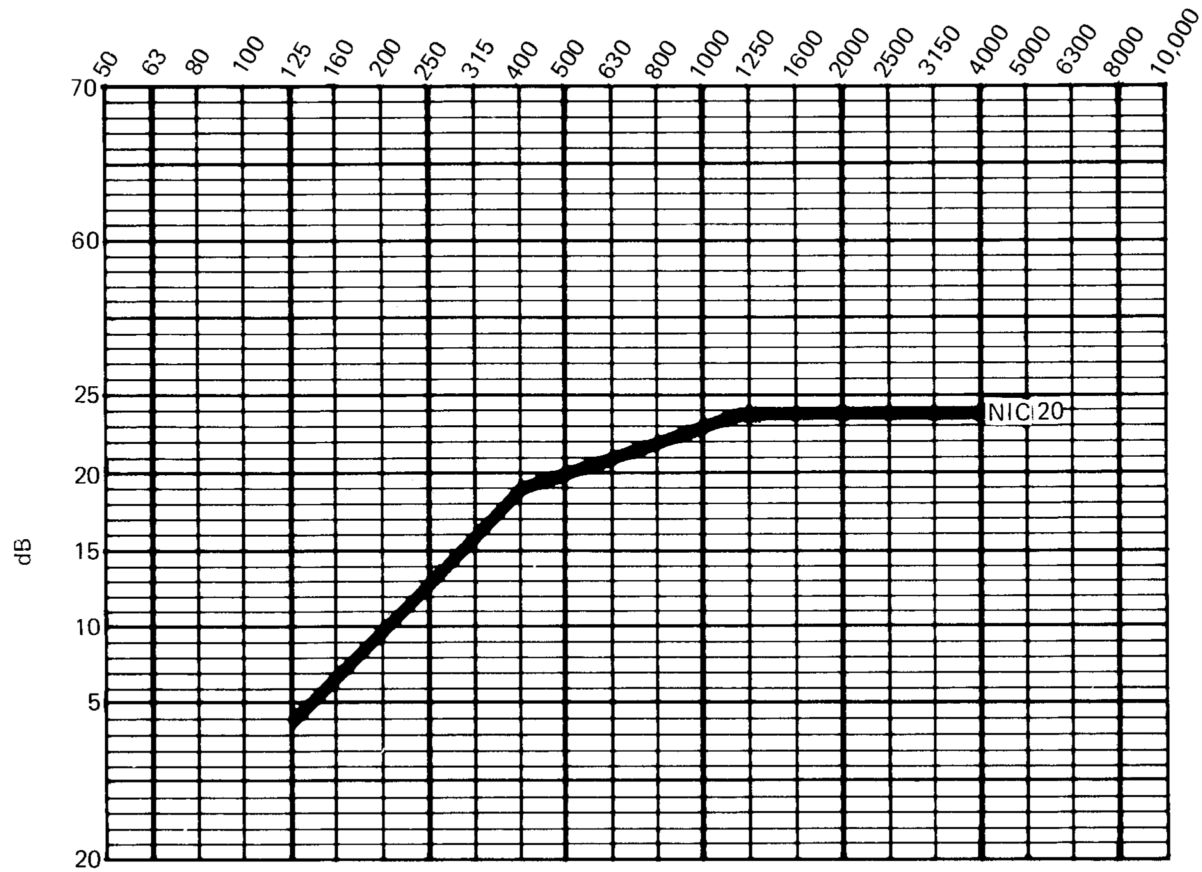

Figure 9. Typical NIC Curve *

The final noise curve, ($NC_{Background}$), can be calculated. The first step is to measure A_I, referenced at 3 feet, and at 1/3-octave intervals within the noise-masking frequency spectrum. For speech privacy the spectrum will be from 400 to 2000 Hz, since this is the range of maximum voice energy. This measurement is made by providing broadband noise at the *source location* in the first zone, taking a reference measurement at 3 feet, and finally making another measurement at the receiving location in the adjacent zone. The difference will be the interzone attenuation. The noise-masking source should be a loudspeaker providing *pink noise* loud enough to overcome the ambient noise level at the receiving location. Plotting these measurements will result in the $NIC_{Interzone}$ curve.

The next step is to assign a numerical value to the desired Speech Privacy Potential (SPP), which will be linear across the frequency spectrum. SPP is defined as the long term rms level of speech peaks at 3 feet from a talker during speech at a specified level. It has been subjectively determined that SPP = 60 for average conversational speech levels; therefore, when calculating a noise curve, the numerical value assigned should be a minimum of 60 for *normal privacy* and 65 for *confidential privacy,* which requires an additional 5 dB of isolation. The difference between the SPP and the $NIC_{Interzone}$ curve will describe the desirable $NC_{Background}$ curve. These criteria can be represented as shown below:

$NIC_{Interzone} \geqq NIC_{20}$

$NC_{Background} \leqq NC_{40}$

$NIC_{Interzone} + NC_{Background} \geqq SPP_{60} \pm 2$ dB (400-2000 Hz)

*See **NOTE** page 8.

$NC_{Background}$ below 400 Hz should fall between NC_{35} and NC_{45}. Above 2000 Hz, it should roll off at 6-12 dB/octave with no discontinuity. Final adjustments will likely be judged necessary on a subjective basis when the system is installed and operating, but should be of a minor nature only. After completing the installation of a noise-masking system, it is advisable to initially energize the system at a relatively low level, gradually increasing the noise level a few decibels per day until the desirable $NC_{Background}$ level is reached. This will gradually acclimatize the people in the area affected and will probably mean fewer complaints of annoyance.

It should be emphasized once again that no economies in speaker distribution or power should be considered or allowed, since this will invariably result in a less than satisfactory system.

In the final checkout of the system, after the spectrum has been shaped, it is appropriate to look at the spectrum as fed electrically to the loudspeakers. It is not at all uncommon to find the level at 10 kHz to be 10 dB higher than at 1 kHz due to the considerable transmission losses at high frequencies through the ceiling material. The power-handling capacity of the line-to-voice coil transformer should never be exceeded.

*** NOTE**

> Although the curves shown in Figures 7, 8 and 9 are on 1/3-octave grids, the levels are determined by 1-octave bandwidth measurements centered at the ISO preferred frequencies.

APPENDIX

INSTRUCTIONS FOR MODIFICATION OF 9860A FOR USE WITH 8080A

This modification provides for the substitution of an 8080A Pink Noise Generator for the normal input transformer of the 9860A Equalizer. This combination provides maximum stability with a high degree of flexibility in tailoring a noise source to the desired spectrum in a wide range of environments.

1. Install a 510-ohm, ½ watt resistor from pin 7 to pin 8 on TB5 (see Figure 10).

2. Install a piece of hookup wire from pin 8 on TB5 to pin 5 on transformer socket S1 (see Figure 10).

3. Install a 1500 μF, 25V dc capacitor from pin 8 on TB5 to a ground lug on C1.

Replace transformer T1 with 8080A (see Figure 11).

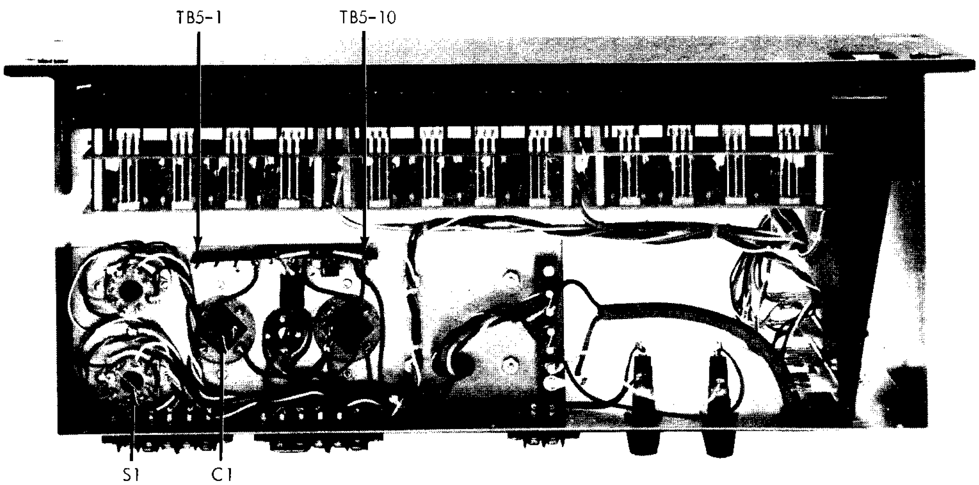

Figure 10. Bottom View 9860A, Cover Removed

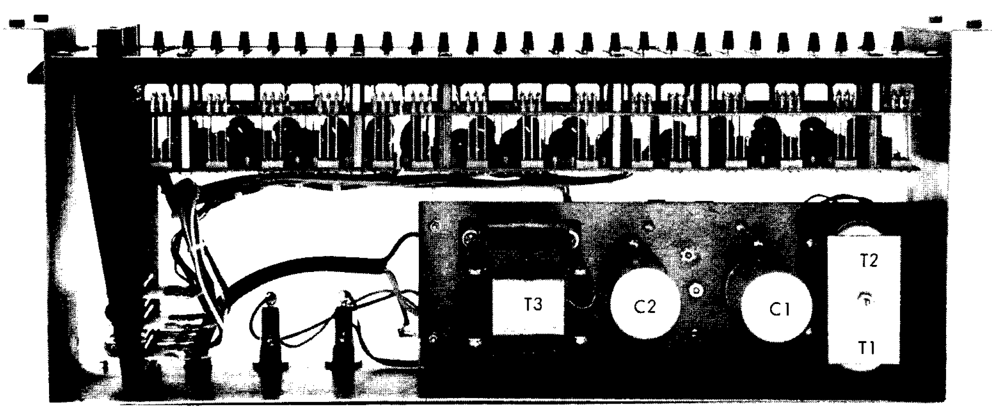

Figure 11. Top View 9860A, Cover Removed

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