Engineering News

ALTEC LANSING 1515 S. Manchester Avenue, Anaheim, California

A Division of LTV LING ALTEC, INC.

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## ESSENTIAL REQUIREMENTS FOR SPEECH REINFORCEMENTS SYSTEM

A speech reinforcement system is required in auditoriums to provide the listener with adequate speech signals when it is not possible to obtain intelligible speech directly from the talker.

There are two required features for such a sound system:

1. Intelligibility
2. Naturalness

Intelligibility is the major requirement, but naturalness is desired so that the listener will not be aware of its operation. To accomplish this, the system should generate only sufficient power to obtain intelligible speech without being unnaturally loud or harsh. Ideally, this would be equivalent to the volume of sound heard directly from the talker at five to six feet.

To be natural, the amplified portion of the sound should not be delayed from that of the original. Delay produces echo and interferes with intelligibility. The amplified sound should seem to come from the talker. The frequency response of the system should be smooth, avoiding peaks and valleys, which contribute to feedback and unnatural sound. In large auditoriums reverberation is generally a limiting factor in intelligibility. For this reason the directivity of the loudspeakers should be sufficient that the side walls and ceiling receive the minimum energy. Where reverberation is high, it is usually necessary to decrease the low-frequency response of the loudspeakers in order to avoid excess energy in the lowest portion of the speech band which causes speech to sound "boomy". Altec amplifiers used for reinforcement have provision to gradually reduce the low-frequency response below 500 cps, which offsets the effects of reverberation.

## CENTRAL VS. DISTRIBUTED SYSTEM

There are two accepted basic loudspeaker systems for speech reinforcement. One method is the single or central type (fig. 1) and the other is the distributed type (fig. 2).

With the central system all of the loudspeakers are placed in one area. As a rule the loudspeakers are placed at a position directly above the talker. The ear localizes sound to a much greater degree in a horizontal plane than vertically. Thus, the loudspeaker can be at a considerably greater distance from the talker in height than it can in width before the original source and amplified portions appear to come from different directions (fig. 3). Proper planning of the layout of the central system will therefore provide the most natural reinforcement. There will be a minimum of echo and time delay between the two sources.

Directional micraphones and directional loudspeakers are an important part of a central system. The directional loudspeaker projects the sound into wanted areas and avoids the side walls and ceiling, which cause reflection and reverberation. The directional microphone reduces the angle of pickup to that necessary to amplify the talker. This permits adequate amplification without feedback. When the loudspeakers are at a considerable distance from the front row, a higher degree of uniformity between front and back rows can be obtained. In those cases where the talker is near the front row, the loudspeaker distance can be achieved by increasing the height. Excellent amplification can be obtained with a central loudspeaker placed about 35 feet above the talker (fig. 3). The hearing mechanism obtains maximum intelligibility from a source when the acoustical energy arrives from a single source position. This is why the central loudspeaker system is recommended for most applications. The exceptions are where the distance between talker and listener is too great, or where low ceilings or balconies do not allow adequate placement of the loudspeakers for uniform coverage. Excessive reverberation may also be a deterrent factor.

A distributed loudspeaker system consists of a plurality of small loudspeakers located a maximum of 15 to 20 feet from the listener. The spacing between loudspeakers is also 15 to 20 feet, depending upon the coverage of each unit.

Such a system relies on the ability of the listener to hear the amplification from only one, or the nearest loudspeaker. Such an ideal situation exists for only a few listeners, most others hear the amplified sound from two or more sources and thus have no illusion that the signal originates at the original source. Therefore, the distributed loudspeaker system will not have the feeling of naturalness. The intelligibility factor is generally poor because of the multiple sources (from adjacent loudspeakers) and the effect of echo is increased. These limitations restrict its use to installations where the ceilings are low and best results are obtained by using acoustic treatment to reduce the reverberation effects of the multiple speakers and any direct transmission of the original talker.

A distributed system should be used only where reverberation is excessive and the geometry of the building is so involved that a central loudspeaker system cannot reach all areas.

A combination of the central and distributed system is practical in many cases. The central system is used for the main portion of the area to be covered and the distributed system is used in the area not within the angle of coverage by the central system.

## EQUIPMENT FOR THE CENTRAL LOUDSPEAKER SYSTEM

To be most effective, it has been pointed out that the loudspeaker system should be as directive as possible. It must transmit the amplified sound to the area of listener and minimize any energy in other areas, particularly ceilings, rear walls, and side walls.

The most directive loudspeakers are of the horn type. Directivity is controlled by the length and mouth area of the horn. The horn becomes increasingly directional with an increase in frequency. To cover the essential portion of the speech frequencies with a single horn requires a length of two to three feet and mouth areas of two- to four-feet square. The larger the horn the more it can be directional at the lower speech frequencies. Generally speaking, the reverberation increases with the size and volume of an auditorium. Shorter horns can be used in small rooms or where the distance between speaker and listener is less than 75 feet. Above this distance the larger horns with increased directivity at lower frequencies give best results.

Typical recommendations would be to use the Altec 511 Sectoral Horn (fig. 4) up to 75 feet and the multicellular group for greater distances (fig. 5).

The multicellular type is made in several configurations so as to fit each area adequately and not distribute energy into unwanted areas; such as ceiling, back wall, and side wall.

Multicellular horns are composed of a group or stacking of individual horns so that each small horn becomes a composite part of the large horn assembley. Each cell has a distribution angle of approximately 20° x 20°. All cells are fed from a common throat and driver unit. The partial spherical front achieved by grouping the cells allows each cell to contribute to the whole without overlap or confusion. The Altec 803, 804, 1003, 1004, 1503 and 1803 are typical of the most directive horns, since they have a useful frequency range to 200 cps. The next series is the 805, 1005, and 1505 horns which are useful down to 400 cps. It is recommended that the 300-cps horns be used in the larger auditoriums, especially where distance and reverberation are great.

Light-weight multicellular horns are now available. They use a new damping material which is sprayed on the outer surface of the horn and provides damping equal to that of the original tar-filled horns. The new horn weight is roughly one-third of the original. This permits lighter and less-expensive frameworks to hold them and simplifies the gondola construction.

Placing the horn high above the source of sound will maintain the illusion of naturalness, reduce the feedback effect, and minimize the amount of sound reflected from the ceiling and back wall.

In many cases it is desireable to reproduce amplified signals below the range of the multicellular and sectoral horns. Cone-type speakers of the eight- to fifteen-inch class should be used. In areas serving up to 200 listeners, one or two eight-inch speakers of the 401, 403, or 755 type are recommended. They should be enclosed in baffles or boxes which are free of resonance. This can be done by providing stiff walls and generous internal acoustic treatment of the Fiberglas type (three- to four-pound density per cubic foot).

The A-7 system (fig. 6) is typical of the best obtainable for systems capable of covering both speech and music in small auditoriums (up to 800 seats). The low-frequency portion uses a short horn and a 15-inch driver. The low-frequency horn aids in securing directivity below 500 cps. This system may be used in several different mounting positions (fig. 6A). Normally, the high-frequency horn is placed above the low-frequency horn. In cases where its over-all height is greater than installation space permits, the low-frequency horn can be placed on its side and the high - frequency horn mounted above or below it. Another approved method is to mount the high-frequency horn in the space directly back of the ports. The center panel is removed. No adverse effect in quality results from this position.

The A-7 may be modified to use the 511 horn and N500-C dividing network to obtain increased directivity. Still greater directivity can be obtained by using the multicellular horns and the N500-C network. This is recommended in difficult situations involving distance and reverberations.

The H210 low-frequency horn and multicellular horn combinations permit the highest possible concentration of power and quality (fig. 7). They are capable of serving the largest auditoriums, sports arenas, or churches for both speech and music.

EQUIPMENT FOR DISTRIBUTION SYSTEMS

For the distributed system, the 755 speaker (flush-mounted in the ceiling) can provide the most uniform distribution. The ceiling spacing, using a 755, can be as great as 25 feet, depending upon the height; usually half the number of speakers as compared to other types need be used. The wide angle of coverage accomplished with the 755 results from the flat cone used. The lesser number of speakers, ceiling cans, and matching transformers usually balance the cost of less expensive eight-inch speakers.

It is often assumed that a 70-volt matching transformer has no loss. This is not true, and it is important to know its insertion loss. A large majority of inexpensive matching transformers have losses as great as 50 per cent, or 3 db. This is equivalent to reducing the available amplifier power from 80 watts to 40 watts. In the interest of over-all installation economy and quality, Altec has provided matching transformers with only 0.5 db insertion loss, which corresponds to ten per cent. In many cases, by using Altec low insertion loss transformers, the actual size of the amplifier can be smaller than one would ordinarily choose--based on previous experience with inexpensive high-loss transformers.