Engineering News

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A Division of LTV LING ALTEC, INC.

Technical Letter No. 158

ACOUSTICAL TUBE DELAY SYSTEM

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GENERAL

In many sound systems it is desirable to provide local speakers to cover area that are screened partially or entirely from the main speaker arrays by overhanging balcony soffits or other obstructions, or to cover overflow areas not satisfactorily reached by the main speakers, or in a stadium equipped with a central speaker system that cannot reach certain areas. To avoid troublesome differences in arrival time of sound from the main speakers and the local speakers it is necessary to delay the sound program fed to the local speakers by the time required for transmission of sound from the main speakers to the area of interest. If the delay is increased by an additional 10 to 20 milliseconds, all the sound will appear to the auditor to originate at the location of the main speakers due to the "precedence effect."

Heretofore, most delay systems have employed magnetic tape record/reproduce equipment, and such systems are usually capable of very good performance. To meet the need for a delay system that does not require the constant attention and maintenance that must be given to tape equipment, Altec has engineered a system based on an acoustical tube, a stock driver loudspeaker, and a stock microphone. With the addition of amplifiers and equalizers, this system is capable of the following performance:

Time Delay:	Up to 160 milliseconds
Frequency Response:	Within ±2.5 db 70 to 6000 cps
Noise:	Better than 50 db below signal for system having 160 ms. delay
Distortion:	Less than 2% THD for the tube and transducers.

DESCRIPTION

Block Diagram, Fig. 1, shows the elements of the system. The acoustical tube is driven by an 806A, the power for which is furnished by a 361A amplifier driven by a 436C compression amplifier. The 436C may be bridged across either the input or the 8-ohm output of the power amplifier connected to the main speaker system. The Pre-Equalizer is included in this chain of equipment to shape the special distribution of the input signal to provide best performance with respect to distortion and signal/noise ratio. The acoustical signal is picked up after traversing a length of tube providing delay T_1 by a 682A microphone mounted in the tube. The microphone output is amplified by a 1578A transistor preamplifier, processed by a Post Equalizer to correct to a flat frequency response, and amplified by a second 1578A and a 361A transistor power amplifier to drive the local speaker.

In many instances more than a single time delay is required, and the block diagram shows a second microphone at a further point in the tube. A similar electrical system would be associated with this and all other microphones used in the system. The number of outputs is unrestricted.

EQUALIZERS

When high sound intensities are produced in air, distortion of some degree always occurs due to unequal expansion and compression properties of the medium, and this distortion in the tube varies widely with frequency. The transmission loss along the tube increases greatly with frequency. The driver and microphone used in the manner prescribed herein have response irregularities that require correction. Due to the complex interplay of these factors, the Pre-Equalizer and Post-Equalizer must be custom-designed for each system to the individual tube length and to the particular driver and microphone in order to realize the performance detailed above.

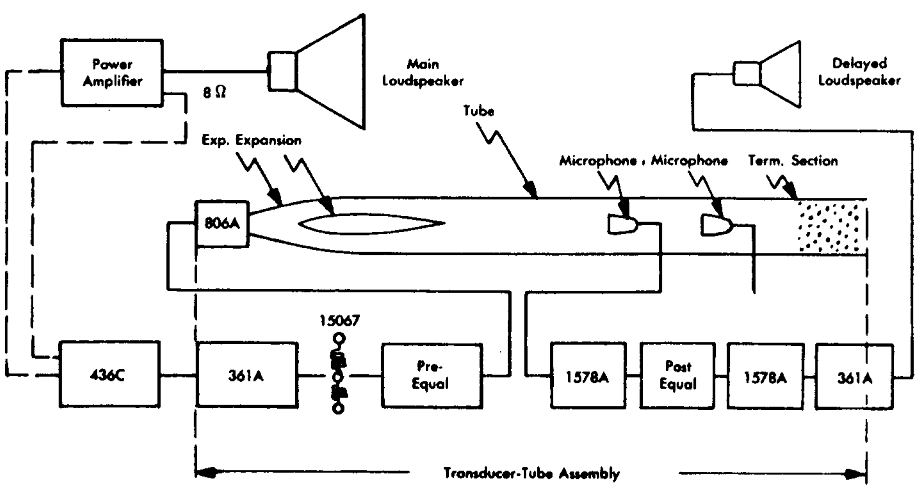

FIGURE 1 — Block Diagram of Acoustical Tube Delay System $856.00 ESV

DRIVING AMPLIFIERS

The 436C is included to provide compression at maximum drive in order to secure a best signal/noise ratio.

The pre-equalizer-806A combination has an input impedance of 40-ohms and requires 20 volts drive (10 watts). The 361A followed by the 15067 in a 4:1 impedance step-up arrangement meets these requirements comfortably.

MICROPHONE AMPLIFIERS

As shown in Fig. 1, the microphone output is fed thru a 1578A Pre-amplifier, thru the Post-Equalizer, and thru a second 1578A to a suitable power amplifier such as the 361A. To provide a convenient and economical arrangement, the Post-Equalizer is designed to plug into ACC #2 socket of the 361A and it provides a socket into which the first 1578A is plugged. The microphone heads are connected to Hi, Lo and G of Input #2 and the output cable of the equalizer connected to Hi, Lo and G of Input #1. The second 1578A is inserted into ACC #1 socket. Gain Control #2 will be ineffective.

TUBE AND TRANSDUCER ASSEMBLY

The complete tube and transducer assembly consists of the following:

1. One 806A Driver Loudspeaker, (order from Altec)
2. One Exponential Coupling (order from Altec)
3. The required number of elbows and straight sections of 2-inch, thin-wall, EMT steel tubing (conduit), and the compression couplings required for joining them, to provide the desired delay. The total length required is equal to the distance from the main speakers to the local speakers plus about 20 feet. Allow 2 feet for each 90° elbow. (Procure locally.)
4. One or more 682A microphones.
5. One 5- or 10-foot terminating section consisting of 2" EMT lightly filled with lamb's wool. This section is joined to the tube following the (last) microphone. The purpose of this terminating section is to load the tube acoustically.

The tube may be laid out in a straight line, or it may be folded or coiled using standard EMT elbows. A 160-foot tube consisting of 12 straight 10-foot sections and 24 90-degree elbows, in a simple stacked arrangement of minimum width, measures about 12½-feet long, 2½-feet wide, and 26-inches high. The same tube arranged for minimum height (that of the 806A) would be 15½-feet long and 5½-feet wide. The length could also be decreased by increasing the width or the height or both. The tube may be supported on the floor or suspended from the ceiling.

It is necessary to avoid contact of one section with another either directly or thru the support structure. Pads of polyurethane foam seem well suited for use as sound-isolation supports.

All cracks and joints in the system, principally at the couplings, must be closed. Satisfactory material for this purpose is a product for household use called MORTITE, manufactured by Mortell Co., Kankakee, Ill. and available at hardware stores.

The tube should be located in a quiet area if possible, particularly in the case of a long tube, as the acoustical level in the microphone end of the tube is very low and pickup of ambient noise may occur. When necessary, a sound-isolation enclosure can be built around the tube and transducer assembly. This should best be made up of 2 sets of 1 x 3" studs, staggered, with ¼" plywood glued to them to form a double-surfaced wall and with ½" plasterboard nailed to both plywood faces (joints must be tight). An enclosure built according to this philosophy should provide 40 db or more to attenuation against outside sounds.

To facilitate moving the microphones experimentally to increase or decrease the delay they may be mounted in a short length of tube as shown in Fig. 2. The rubber bands shown will grip the microphone and will isolate it from structural vibrations.

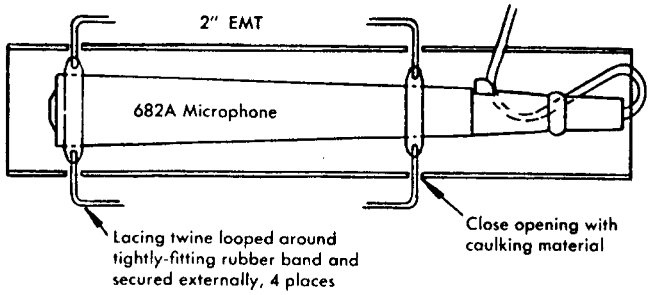

FIGURE 2 — Microphone Chamber

TESTING

Time delay in milliseconds equal to 91% of the distance in feet between the main and local speakers would be expected to eliminate all time difference at the local speakers, but this will not usually be the ideal amount of delay. If the delay is increased 10 to 20 milliseconds the "precedence effect" will cause the listener to feel that the sound comes only from the main speakers even when the level from the local speakers is up to 10 db greater at the ear. The area to receive sound from local speakers is not usually definitely defined, and the fringe areas must be explored. Areas forward of the local speakers receive sound from the main speakers with less delay, and the tube delay used could prove to be excessive in these areas. These are some of the reasons for carrying out listening tests over the entire area affected with the tube length varied in 5- or 10-foot intervals. Speech or other material rich in transients would be suitable for this purpose.

ADJUSTMENTS

To determine the gain setting for the 436C, establish the highest output of the main speakers that might be required under any condition. Adjust the 436C control to 10 or 15 db compression under this condition. Using an oscillator to provide a steady signal, raise the oscillator level sufficiently to produce the same compression and adjust the control of the 361A for 20 v output. This control and that in the 436C should be locked in position. The gain of the 361A which drives the local speakers will be adjusted to meet volume requirements in the area covered, and it is not usually necessary to lock this control.

LIMITATIONS

The high attenuation occurring in the tube results in low acoustical level at the microphone with the result that the microphone output may not be sufficiently above amplifier noise or its input above ambient noise in the case of very long tubes. There is not yet sufficient experience with the system to establish limitation of length for various uses, such as indoor, outdoor, or noisy area applications for a carefully engineered system provided with isolation from ambient noises. An experimental system has been operated, using 1½-inch tube 160 feet long, coiled and stacked, equalized with ± 1.5 db from 65 to 7000 cps, which performed with a S/N radio of 43 db without compression and 53 db with 10 db of compression.