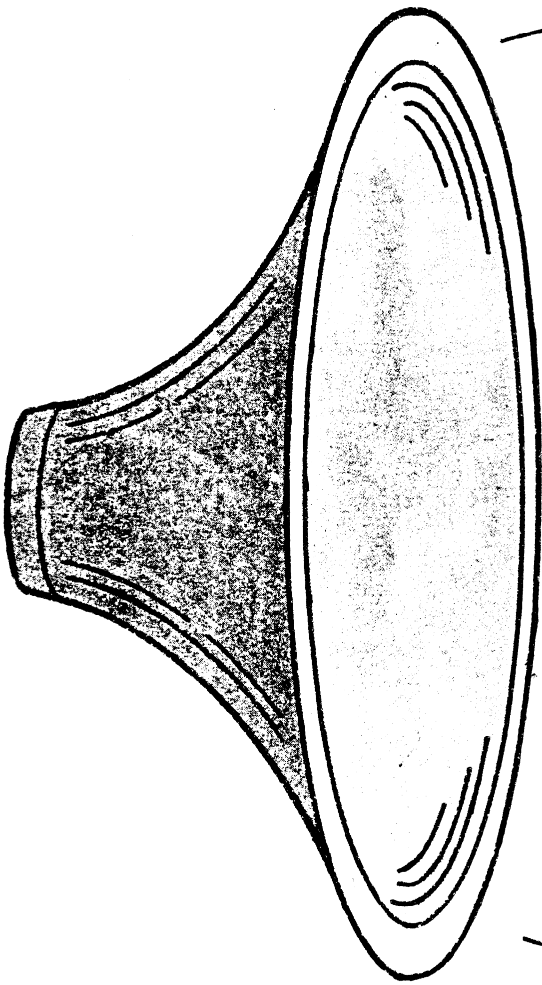
# BOGEN



- Cone Speakers
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# SPEAKER INSTALLATION INSTRUCTIONS

# INTRODUCTION

No matter how excellent the amplifier, if the speaker installation is incorrectly or poorly arranged, sound reproduction will be correspondingly inferior.

There are numerous factors to be considered in a speaker installation, and the following paragraphs are designed to assist the installer in solving some of these problems. The text which follows is of necessity limited, for many volumes have been written on this subject. Included in the text are the major fundamentals of speaker installation along with general hints to be followed for more efficient and lasting installation.

Occasionally unusual situations may arise which are not covered here. When this happens, consult a qualified source of information, a more complete text, or a competent sound technician or engineer, before continuing with the installation.

# CONE OR HORN SPEAKERS

There are four primary considerations in installations utilizing standard cone or horn speakers:

1. Power available to speakers
2. Number of speakers
3. Type of speakers
4. Placement and connection of speakers

The first step is to survey the proposed installation and carefully determine how many and what type of speakers are needed. The following table may be of aid in this respect.

| AMPLIFIER POWER | SPEAKERS NEEDED FOR INDOOR INSTALLATION | SPEAKERS NEEDED FOR OUTDOOR INSTALLATION |
|---|---|---|
| 6 to 8 w | Two 8-in. speakers | One 12-in. speaker |
| 15 to 18 w | Two 12-in. speakers | One trumpet |
| 25 to 30 w | Four 12-in. speakers | Two trumpets |
| 45 to 50 w | Six 12-in. speakers | Three trumpets |
| 60 to 70 w | Eight 12-in. speakers | Four trumpets |

There are several types of speakers available, and the choice of speakers is dependent upon five main factors:

1. Geometry and acoustical characteristics of the area to be covered.
2. Ambient sound level in which the speakers must operate.
3. Fundamental use of the system (i.e. - speech or music reproduction.)
4. Fidelity and intelligibility requirements.
5. Economic factors.

## Speaker Placement

The most complex step in speaker installation is that of the placement and connection of speakers. Conditions under which each system must operate vary so widely with each installation that only the primary steps will be given here for consideration in placement of the speakers. For indoor systems, two kinds of placements can be used. The speakers may be placed flat against the walls, and the axis of the speakers rotated so that they radiate energy at an angle from the wall. The speakers may also be placed in the corners of a room. Variation from these two basic arrangements must be considered where there are alcoves, balconies, booths, dividing walls, and side rooms. In such cases, thought must be given to proper placement of extra speakers in order to prevent dead spots resulting from unusual reverberations or blanking out by obstacles.

For outdoor systems, the main considerations are direction of sound and the area to be covered. Here, the brute-force technique is generally used by employing highly-directive trumpets. Bear in mind that sound pressure is reduced approximately 75% below the previous level each time the distance from the speaker is doubled. Also, directivity (amount of power concentrated along the speaker axis) increases with the size of the speaker horn.

## Speaker Connections

In connecting the speakers together, consideration must be given to impedance matching and phase relation. Since these considerations are somewhat involved, an extended discussion of impedance matching and speaker phasing is provided below.

Efficient transfer of power from the amplifier to the speakers is the prime consideration in sound system connection. The two methods of transfer of power are connection from the amplifier directly to the speaker voice coils and connection from the amplifier to the speaker voice coils through a transformer. The first method is employed when short runs of wire not over 200 feet in length and simple speaker arrangements involving low impedances are used.

The second method is employed when the wire runs are over 200 feet, when there are complex speaker arrangements, and when it is desired to have less than 15% power loss in the transmission lines. The use of transformers also simplifies impedance calculations, and facilitates changes in complex speaker arrangements.

## Impedance Matching Without Transformers

For the most efficient transfer of power, it is important that the total speaker impedances match the output impedance of the amplifier.

Single speakers should be matched as shown in figure 1.

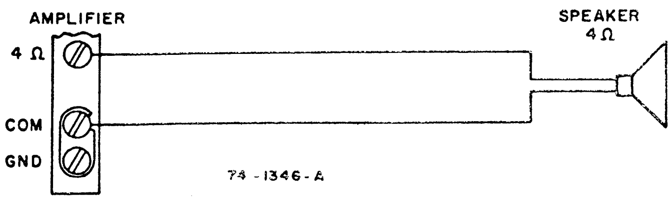


*Figure 1 -- Matching Single Speaker*

When there is more than one speaker in a sound system, calculations of total speaker impedance are based upon two formulas:

(a) For series connection of speakers, add the individual speaker impedances together to obtain the total matching impedance: (See figure 2)

$$Z_T = Z_1 + Z_2 \ldots\ldots + Z_n$$

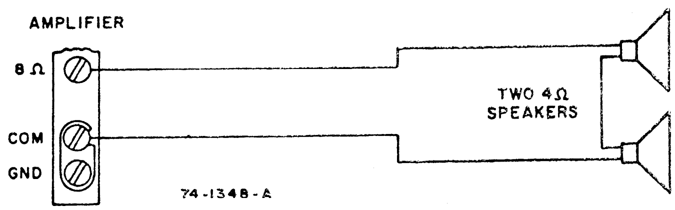


*Figure 2 – Matching Two Speakers Connected in Series*

(b) For parallel connection, add the reciprocal of the individual speaker impedances together to obtain the reciprocal of the total matching impedance: (See figure 3)

$$\frac{1}{Z_T} = \frac{1}{Z_1} + \frac{1}{Z_2} \ldots\ldots\ldots \frac{1}{Z_n}$$

It is generally not advisable to use more than two speakers in parallel. Operation with less than 4 ohms impedance will result in excessive line losses.

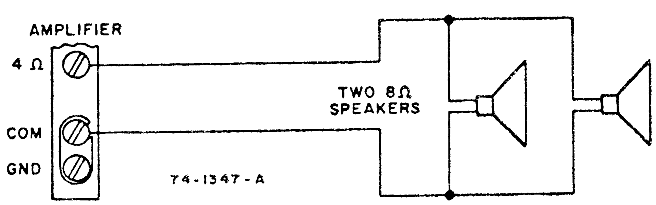


*Figure 3 – Matching Two Speakers Connected in Parallel*

(c) For series/parallel connections, combine the two formulas as the speaker connections indicate. For example, in Figure 4, apply the series formula for A and B, then for C and D. Take the results of this and apply the parallel formula to obtain the final matching impedance:

(1) $A + B = X$

(2) $C + D = Y$

(3) $\frac{1}{Z_T} = \frac{1}{X} + \frac{1}{Y}$

(4) $Z_T = \frac{XY}{X+Y}$

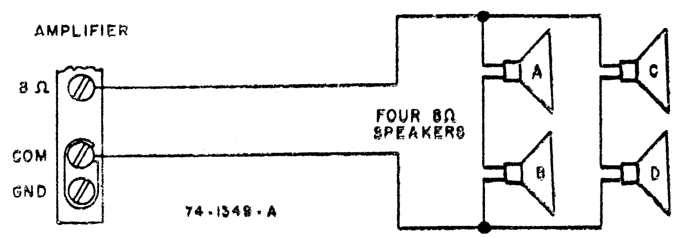


*Figure 4 -- Matching Four Speakers Connected in Series Parallel*

## Power Distribution With Transformers

In a series system of speakers, with like voice coil impedances, equal power distribution will occur. However, if one speaker has 4 ohms impedance and another 8 ohms, the power consumed by the 8 ohm speaker will be twice that of the 4 ohm speaker.

In parallel systems of speakers with like voice coil impedances, equal power consumption will result. When speakers of different impedances are connected in parallel, the smaller impedance speaker will receive the greater power. If one speaker is 8 ohms and one is 16 ohms, the 8-ohm speaker will consume twice as much power as the 16-ohm speaker.

When operating speakers on voice coil impedance (without transformer), use as heavy a wire as possible. Speaker cable runs of 100 feet or over should be at least #16 wire. Runs from 50-100 feet should be #18 wire or larger.

## Impedance Matching With Transformers

The proper use of transformers with speakers far from the amplifier prevents the occurrence of comparatively large power losses in the transmission lines. In complex installations having large numbers of speakers, the use of transformers simplifies power distribution

Constant voltage transformers are most commonly used for this purpose, though impedance-matching transformers may be employed in some sound installations. The constant voltage transformer has its secondary tapped for different values of power (watts) for the speaker. The primary matches the constant voltage line, which is either 25 volts of 70 volts.

## Constant Voltage System

The constant voltage system was developed particularly for use in large multi-speaker installations, but that does not prevent smaller installations from enjoying its advantages.

The constant voltage method greatly reduces the amount of computation necessary to determine the proper transformer taps when varying sound levels are required. It also permits the addition to, or changing of, an existing system without recalculation of the total impedances and the power required.

A favorable load condition will exist if the total power consumed by the loudspeakers is always less than or equal to the amplifier rating.

When the constant voltage transformer taps are marked in watts:

1. Choose the transformer with a matching secondary (i.e., 8-ohm secondary for an 8-ohm speaker).
2. Select the power tap desired, and connect to speaker.
3. Connect the constant voltage line to the primary.

If the transformer is marked in impedances, the required power can be determined by applying the formula:

$$Z = E^2/P$$

Where Z = Required transformer impedance in ohms
E = Amplifier output voltage (25 or 70 volts)
P = Desired power at the speaker in watts

For use with constant voltage distribution systems, Bogen has a line of constant voltage transformers selected for 25 or 70 volts, as listed below:

## Constant Voltage Transformers

| MODEL | VOLTAGE | SEC. TAPS (WATTS) | SPEAKER IMPEDANCES |
|---|---|---|---|
| T4 | 70 | 4, 2, 1, ½, | 4 |
| | | 2, 1, ½, ¼ | 8 |
| T16 | 70 | 16, 8, 4 | 4 |
| | | 16, 8, 4, 2 | 8 |
| TS-2 | 25 | 2, 1, ½ | 8 |
| TS-05 | 25 | ½ | 8 |
| TS-025 | 25 | ¼ | 8 |
| TS-16 | 25 | 16, 8, 4 | 8 |
| | | 16, 8, 4, 2 | 16 |

## Mismatching Speaker to Amplifier

Mismatching upward (i.e., connecting an 8-ohm speaker to the 4-ohm output of an amplifier) will affect the power delivered to the speaker. Power loss will be about proportional to the upward impedance mismatch (i.e., 50 per cent when connecting an 8-ohm speaker to a 4-ohm amplifier tap). Mismatching cannot ordinarily damage a well-designed amplifier.

As a general rule, no serious frequency response deficiency will be noted if upward mismatches up to about five-to-one ratio are used. The effect will be less noticeable the higher the amplifier quality.

Downward mismatching (i.e., connecting a 4-ohm speaker to an 8-ohm amplifier tap) should always be avoided. It will reduce the amplifier power output and overload the output tubes or transistors, seriously affecting their life and performance.

## Phasing of Speakers

When employing more than one speaker in a sound system installation, it is advisable to phase the speakers in order to reduce the cancellation effect. Speakers out of phase will lose up to one-half of their normal volume and will operate with degraded tone quality and increased distortion.

For speakers facing in the same general direction, the speakers are in phase when their respective diaphragms move outward and inward at the same time. With two speakers facing each other, proper phasing is achieved when the diaphragm of one speaker moves outward as the diaphragm of the other speaker moves inward.

Phasing is accomplished by checking the polarity of the speaker terminals with respect to the movement of the speaker diaphragm, and connecting the speakers so as to produce the diaphragm movement or phasing desired. With loudspeakers of the same make and model, the respective diaphragms should move in the same direction when the terminals are connected in the same manner, but it is safer to check the polarity as described below.

Where different speakers are used, carry out the following procedure to determine the diaphragm movement with respect to the speaker terminals for speakers connected in parallel:

1. Connect one lead from a 1.5-volt dry-cell to one voice coil terminal of the speaker.
2. Momentarily touch the other lead from the dry cell to the other speaker terminal.

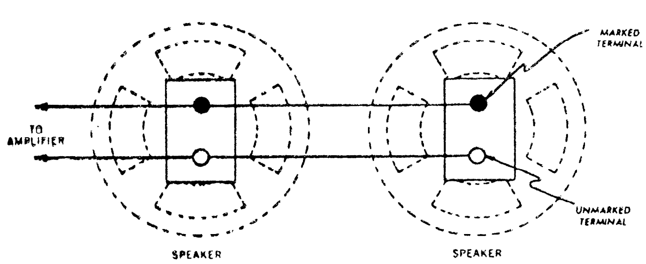


*Figure 5 – Phasing Speakers Facing in the Same Direction and Connected in Parallel*

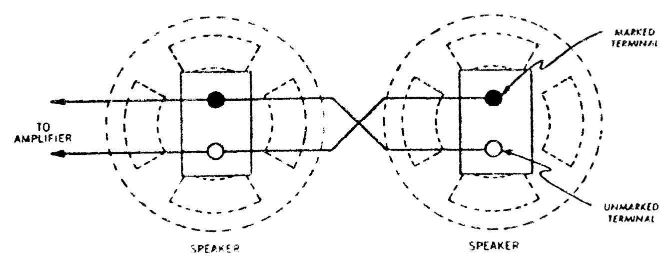


*Figure 6 – Phasing Speakers Facing Each Other and Connected in Parallel*

3. Observe direction of cone or diaphragm movement (either inward or outward) when the circuit is closed.

4. Note this direction of the movement on a slip of paper.

5. Mark the terminal connected to the positive pole of the dry cell if the movement is outward, mark the terminal connected to the negative pole if the movement is inward.

6. Repeat steps 1 through 5 for other speaker or speakers to be checked.

7. Connect the marked and unmarked terminals according to the manner of electrical arrangement shown in figure 5 if the speakers are facing in the same direction. If the speakers face each other, make connections as shown in figure 6.

In simple sound systems, it may be easier to check phasing by listening to a low audio frequency while alternating the speaker leads. The human ear can usually detect when the low frequency sound is at the higher volume, indicating that the speakers are properly phased.

### Balanced Line Connections

In most sound installations, unbalanced speaker lines will provide satisfactory performance. A typical unbalanced line installation for a 25-volt system is shown in figure 1. Two-conductor unshielded cable is normally employed in such installations. One conductor is connected to the 25-volt terminal on the amplifier output strip. The other wire goes to the common terminal, which is then connected to ground. On Bogen amplifiers the COMMON terminal is connected by a shorting link to the GROUND terminal.

However, in more elaborate systems where input lines are run in close proximity to the speaker lines for extended distances, currents in the speaker lines may be picked up by the input lines. When these stray currents are fed back to the amplifier, hum and cross-talk will be introduced into the system, or the amplifier may oscillate.

For this reason, balanced line connections are recommended for installations in which long input and speaker lines are run close together. A balanced line is obtained by ungrounding the common terminal, leaving the outputs floating. In a balanced line, any current which is developed in one side of the line is offset by an equal and opposite current in the other side. This greatly reduces the possibility of inducing stray currents in nearby input lines.

In some balanced line installations, it may also be necessary to connect the appropriate center-tap terminal to ground, and to ground the amplifier chassis. Most Bogen amplifiers are equipped with both 25-volt and 70-volt center-tap terminals.

If hum or other pickup is encountered with a balanced line as described above, it may be necessary to run a shielded two-conductor cable to the speakers and to ground the shield at the amplifier end. A balanced speaker unit utilizing a shielded pair cable in a 25-volt system is shown in figure 7.

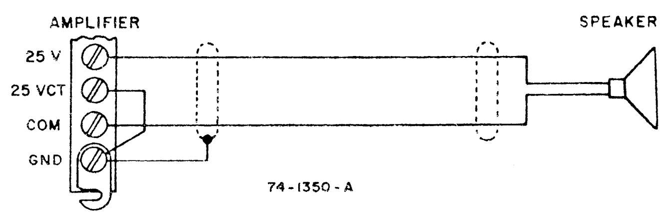


*Figure 7 – Balanced Line Speaker Connections Utilizing Shielded Pair in 25-Volt System*

# SOUND COLUMNS

### Theory Of Operation

Sound columns are designed for sound reinforcement in theatres, auditoriums and arenas where it is necessary to cover a large area with a minimum number of speakers. A sound column consists of six or more cone loudspeakers enclosed in a rectangular cabinet lined with acoustic material. Depending on the size and type of cone speakers employed, the output rating of a sound column may range from 25 to 200 watts. The terminal strip and sometimes a plate for mounting a line-matching transformer are located on the rear panel.

The arrangement of the speakers in the column is such that their acoustic output adds up in the forward direction, so that the effective throw of the sound column far exceeds that of the individual cone speakers. The effective throw or maximum distance at which sound from the column is distinctly audible is usually between 100 and 200 feet.

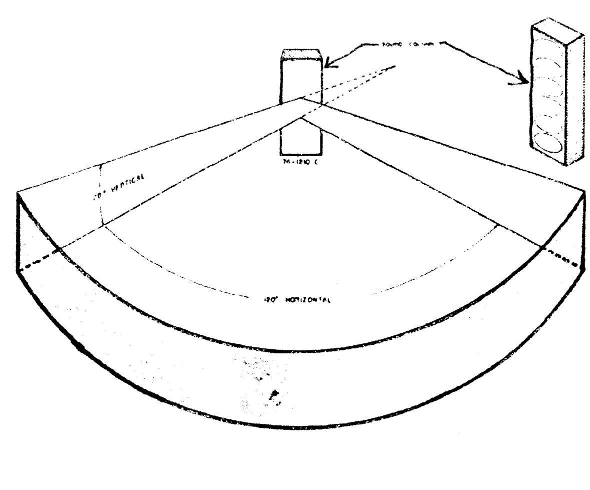

*Figure 8 – Horizontal and Vertical Sound Dispersion Pattern of Sound Column*

Because of its configuration, the sound column produces a highly directional beam pattern, which permits the sound to be aimed over a well-defined area of the installation site. Since about 90% of the acoustic output of the column is confined to this pattern, there is virtually no random sound available to cause reverberation or reflection. Consequently, a sound column can be properly directed to cover a hall or section of a hall most effectively and to keep harmful reflections away from the floor and ceiling.

In addition, the geometrical configuration of the speakers in the column produces a sound dispersion pattern which is quite broad in the horizontal plane but much narrower in the vertical plane. In the Bogen sound columns, the horizontal dispersion pattern is 120°, which is a great deal more than that of the individual speakers. However, the cumulative effect of the in-line speakers produces a vertical dispersion pattern of approximately 25° as shown in figure 8.

## Locating Sound Columns

A typical sound column installation is shown in figure 9. The sound column is placed in the general vicinity of the original sound source (singer, speaker), as close as practicable to the source. Having the loudspeaker sound originate near the original source provides a more natural effect for the audience, and avoids confusion of the performer which would result if he heard an echo of his words from a loudspeaker located far enough away to cause an appreciable time delay.

The column is placed so that the microphone is below and slightly behind the sound column, to minimize feedback. The sound column is oriented so that its vertical distribution will deliver nearly equal loudness to all listeners, from front to back, except those who are within the effective range of the speaker's

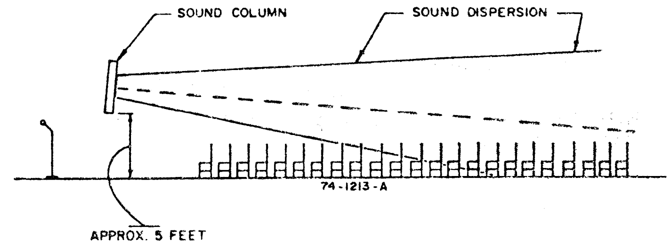


*Figure 9 – Typical Sound Column Installation*

voice. This will usually require that the column be aimed at a point located approximately two-thirds of the way to the rear of the audience.

A sound column can be aimed quite accurately at this point by the light reflection method. Attach a small mirror to the face of the column center. Standing at the aiming point with a light directed at the sound column, have the column adjusted for maximum light reflection from the mirror. In other words, a line drawn at an exact right angle to the column is the center of the strike point.

## Connecting Sound Columns

One or more sound columns may be connected to an amplifier in a sound system. The columns are normally connected in parallel as shown in figure 10.

Sound columns normally have an impedance rating of 16 ohms. If only one sound column is used, connect the amplifier leads to the 16-ohm output terminal. For two sound columns in parallel, connect the leads to the 8-ohm terminal.

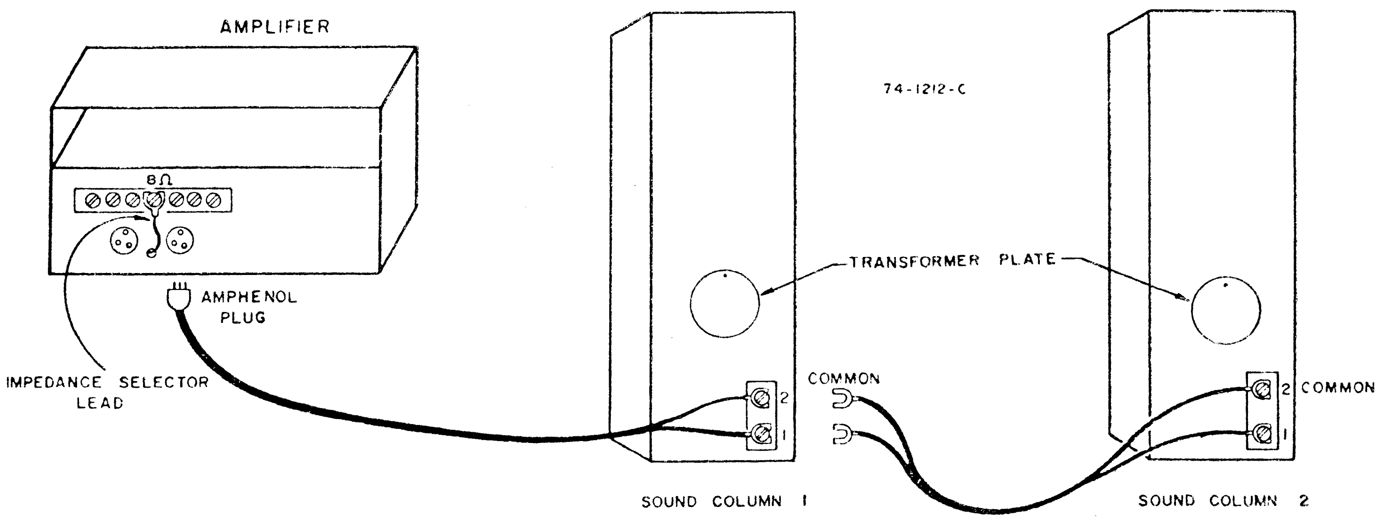


*Figure 10 – Connecting Sound Columns to Amplifiers*