ACOUSTICS

LECTURE 5

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Control of Reverberation Time

In order to obtain the value of the optimum reverberation time with a given volume, it is necessary to control the total absorption of the surfaces. This result is achieved by proper adjustment and distribution of absorbing materials over the various surfaces.

The first step in planning the acoustical treatment of a room is to determine the optimum reverberation time and to find the total number of square-meter units (Sabine) of absorption required to give this the value of this reverberation time.

As a general rule, the surface surrounding the stage should reinforce by useful reflections. On the other hand, the rear wall must be designed so that long delayed reflections from it are prevented from reaching the audience.

This requirement usually necessitates the use of a highly absorptive rear wall. After allowance have been made for the rear wall treatment, the remainder of the required additional absorption should be distributed on the side walls, preferably in patches, strips or panels having dimensions of the order of 1 to 2 m.

The application of non-uniform application can be worked out in many ways, some examples follow:

1- Finish the entire wall with a material such as plywood applied to furring strips. The perforate some of the panels with small halls and back these perforated panels with an absorptive blanket, and thus obtain patches of absorption in such numbers, size and locations as will give the desired reverberation and diffusion.

2- Finish the entire wall or large portions of the wall with perforated board and install absorptive material behind selected portions of the perforated covering. Thus, although the appearance of the surface in uniform, a non –uniform absorptive treatment is obtained.

3- Treat the selected panels, strips (horizontal or vertical), or splays with absorptive material as required to give the optimum reverberation time and good diffusion.

The reverberation time of a balcony can be calculated in the following manner:

a- The reverberation time of a balcony recess is not greater than twice the height of the opening, the volume under the soffit is added to the volume of the main part of the auditorium and the reverberation time is computed as usual.

b- When the depth of the balcony recess is greater than twice the height of the opening, it is necessary to make separate calculations for each of these spaces.

Elimination of Acoustical Defects

1- Echo: An echo is a wave which has been reflected or otherwise returned with sufficient delay to be detected as a wave from that which is directly transmitted. A multiple echo is a succession of separate echoes coming from a single source.

The time difference between two sounds needs to be 0.05 to 0.1 seconds before the ear can detect them as two independent sounds. A number of methods, which can be used to prevent echoes are described below.

Echoes are often caused by reflections from the rear walls because the length of a room is generally greater than the height. If the distance between the front row and the rear wall is more than 10 to 15 meter, special precautions should be taken to reduce the risk of echoes.

There are three possible ways of doing this:

1- The rear wall can be treated with sound absorbing material having high absorption coefficient throughout the whole frequency range. This method has been used extensively, especially in cinemas.

2- The rear wall can be designed as a diffusing surface. This means does not prevent reflection from the rear wall and a risk of echoes still exists if the side wall have low absorption coefficients.

3- The rear wall can be splayed and thus used as a reflectors, increasing the sound intensity at rear seating area.

A concave rear wall is very dangerous because the reflected sound wave may be concentrated in a small part of the room and cause echoes. The corner between a vertical rear wall and a horizontal ceiling is often responsible for the echoes, because the rays of the incident and reflected sound waves are parallel.

A splay between the ceiling and the rear wall can convert a dangerous reflection into a beneficial one.

A high ceiling in a room might cause echoes, especially if the ceiling is concave.

A special type of echo is the so-called flutter echo, i.e. a rapid succession reflected sound. It is usually occurs between a pair of parallel walls in a room. This kind of echo can be eliminated by using non parallel walls or by breaking up the wall surfaces.

2- Sound Concentration: Often referred to as "hot" spots, sound concentrations are created by sound reflections from concave survaces. The loudness of sound at these "hot" spots is unnaturally high, which always happens at the expense of other parts of the room, called "dead" spots create a non-uniform distribution of sound energy in rooms. The elimination of this phenomenon is an important goal of room acoustics. A

typical example of undesirable sound concentration can be observed near a speaker whose sound is reflected back to him from adjacent concave surfaces.

3- Sound Shadow: Under-balcony spaces, with a depth exceeding twice the height, should be avoided, since they will prevent the remote seats underneath from receiving a sufficient amount of direct and reflected sounds, creating thereby poor audibility in this region of auditorium.

Sound Amplification System: The sound level can be increased in the rear portion of an auditorium if:

- The shape and volume of the room are acoustically favorable,
- Suitable reflective surfaces have been provided,
- Reverberation time is optimum,
- Acoustical defects have been successfully eliminated, and
- Disturbing noise has been reduced.

In large halls, however, even thought has been given to these aspects, speech level will be too low for satisfactory hearing conditions. In large auditoria, therefore, and also in outdoor locations, a sound amplification system is always used for good distribution of sound.

It is not possible to specify the exact size or volume of small or medium size auditoria above which a sound system is needed. This will depend on the acoustical conditions of the room, the strength of the voice of the speaker, the distance between speaker and listeners and on the background noise in the room.

According to L.L.Beranek, in an acoustically well designed auditorium, a sound system will be needed if the room volume exceeds about 2000 m^3, and if the voice must travel more than about 25 m to a listener. On the other hand, a sound amplification system may be required in auditorium

having a volume greater than about 4000 m^3 if the room is heavily treated with absorbing materials, and the distance between sound source and listeners exceeds 12 m.

System Component: Every sound amplification system consists of three essential components: microphone, amplifier and loudspeaker, figure (4.1). The microphone placed near the actual sound source, picks up the sound energy radiated by the source, converts it into electrical energy and feed it into amplifier. The amplifier increases the magnitude of the electrical signal and delivers it to the loudspeaker, which converts the electrical signal into air-borne sound waves for distribution to the listeners at a required level.

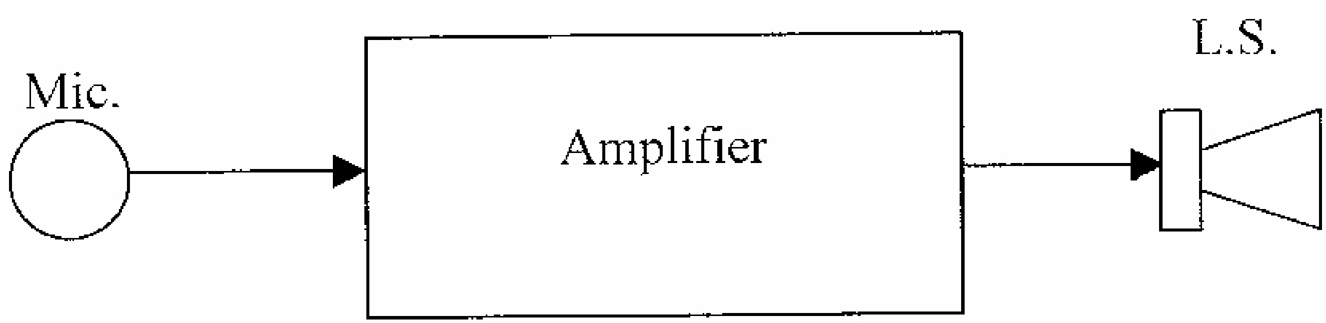

Figure (4.1): Sound amplification system.

Loudspeakers Placing: In most cases, the sound emitted by the loudspeakers is picked up by a microphone close to the natural sound source. A simple central installation is dedicated schematically in figure (4.2). The location of loudspeaker, its directionality and its orientation have to be chosen in such a way that the audience is supplied with sound as uniformly as possible. This can be checked experimentally. In most cases, the loudspeaker will be mounted above the natural sound source, its actual position must be chosen that feedback becomes as little as possible. This method of mounting has the advantage that the direct sound coming from the loudspeaker will always arrive from roughly the same direction as the sound arriving directly from the sound source.

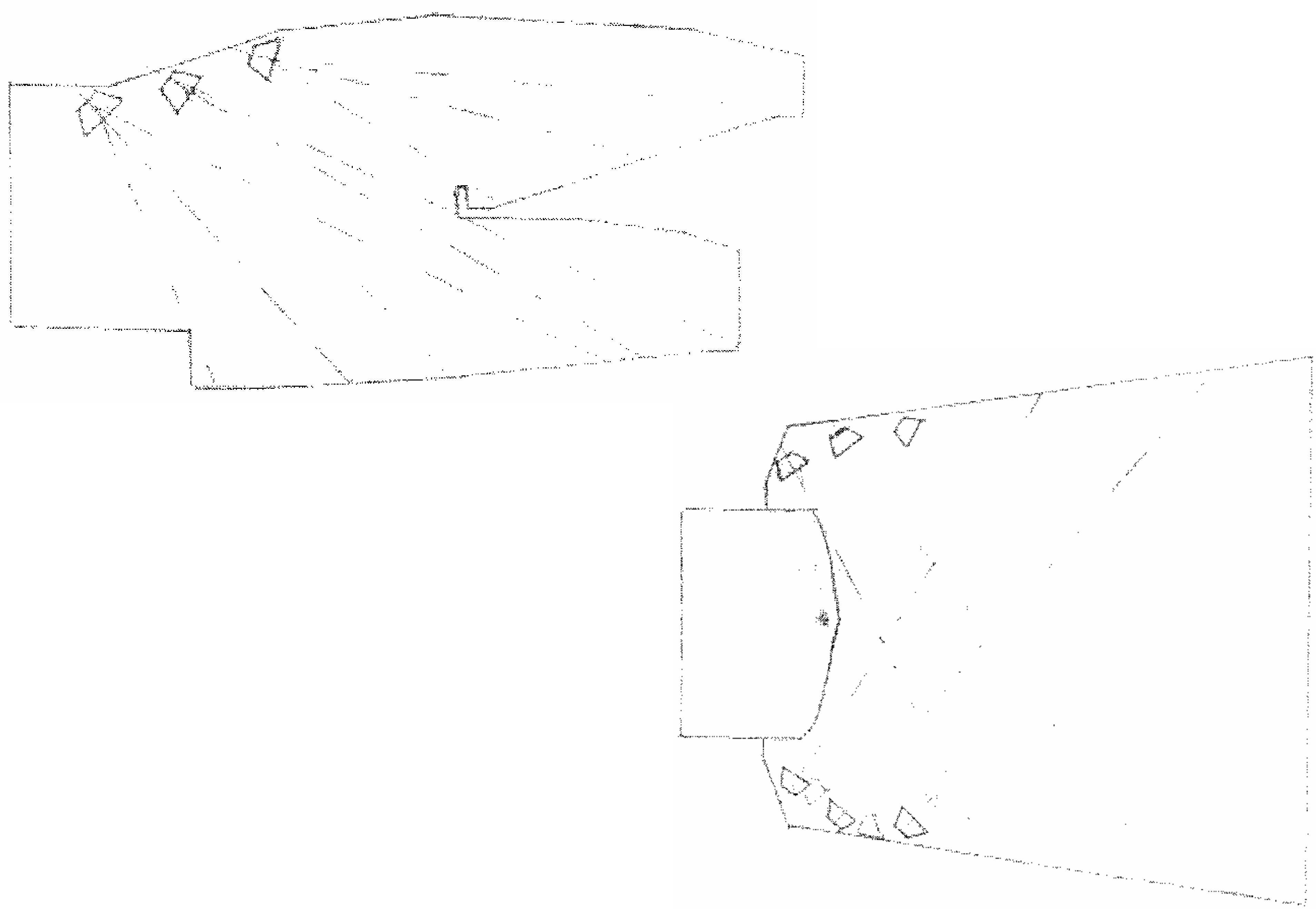

Figure (4.2): Centrally located loudspeaker.

In very large or long halls, or in halls consisting of several sections, the supply of sound energy will depend on several loudspeakers at different points as seen in figure (4.3).

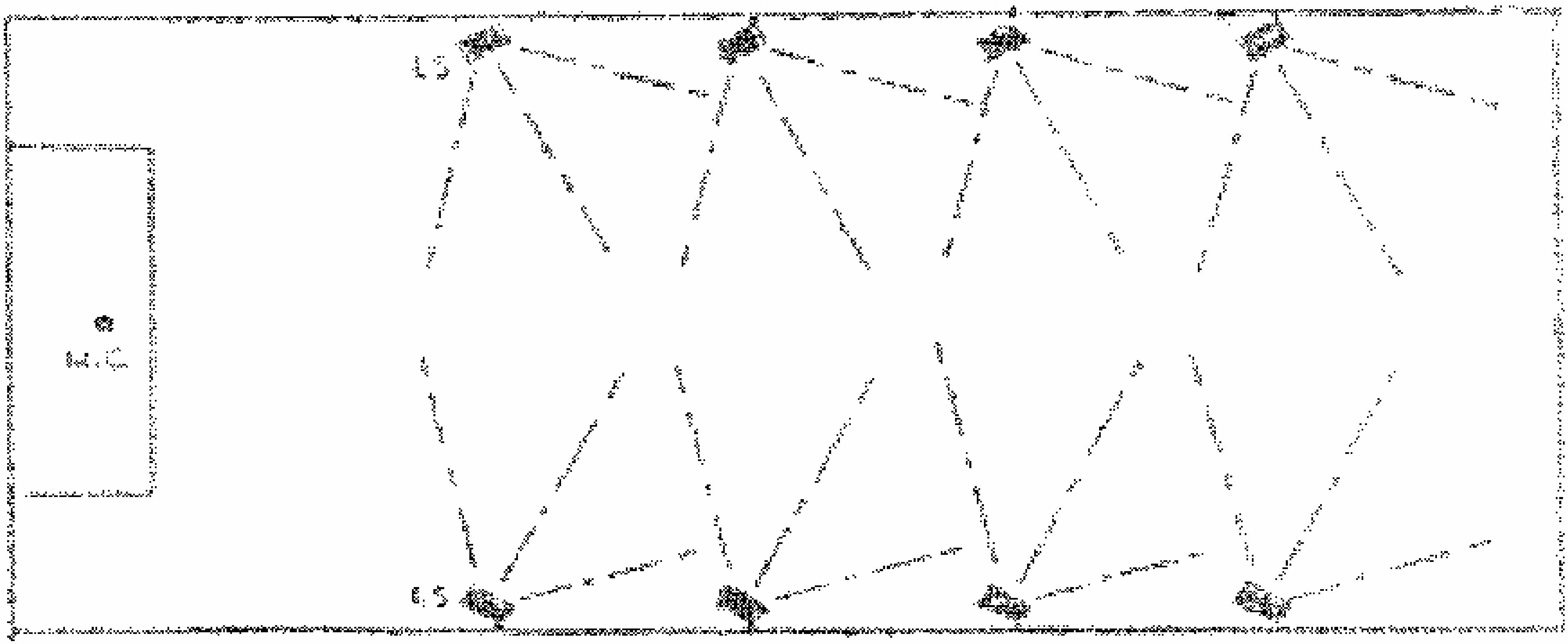

Figure (4.3): Distributed loudspeaker.

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