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# REFLECTED WAVE INFLUENCE ON LOW-FREQUENCY SOUND MEASUREMENT

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## INTRODUCTION

In this report, we study the characteristics of low-frequency sound (below 100 Hz) near reflecting surfaces, develop a microphone-placing technique, and determine the influence of reflecting surfaces on measurements. We also develop a new measurement method called the synchronized-integral method and demonstrate its low-frequency sound measurement efficiency.

## MEASUREMENT SYSTEM

In this experiment, we constructed a speaker cabinet capable of generating a sound pressure level greater than 90dB over a frequency range of 8 to 125 Hz at a point one meter from the sound generator. We then connected a synchronized-integral level meter sound source section to the speaker via a 1/1 octave analyzer and power amplifier. On the receiving side, we connected a low frequency sound level meter to the synchronized-integral level meter via a 1/1 octave band analyzer. The synchronized-integral level meter contains sound source sections and receiving sections. In each synchronized sound source section, the necessary signal ranges are turned ON and OFF at appropriate times. The receiving side is synchronized to the duty cycle of the generator and measurements are accumulated over several cycles. After the measurements are completed, each value is divided by the number of measurements taken. After correcting for background noise, the sound-pressure level at a receiving point is obtained. Using this method, signals well below the noise level can be measured.

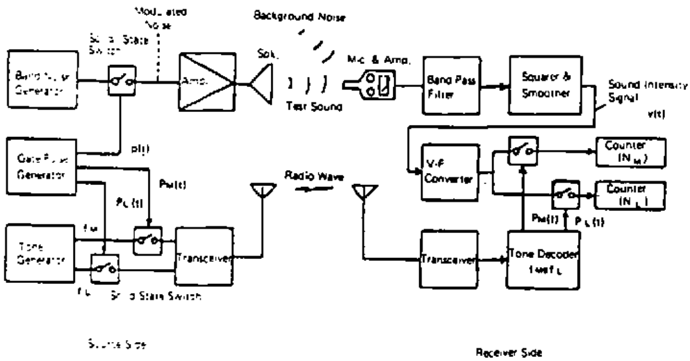


Fig 1 Synchronizing-integral method

Given the sound-pressure level at the sound source, the attenuation to the receiving point can be easily calculated. Fig. 1 indicates a block diagram of the synchronized-integral level meter.

## MEASUREMENT METHOD

Studying the influence of reflecting objects like buildings requires precise sound source location. The results are then compared to the distance attenuation characteristics of sound that is free of reflecting influences other than the ground. We used a controllable sound source to make measurements to determine the size of the reflecting boby, the sound source location, and the influence of sound source frequency variations. In the experiment, the sound center height was 0 and 1.2m, while the microphone height was 0, 1.2, and 2.4m. Four reflecting surfaces were selected: 25m wide x 7m high, 13m wide x 4m high, 3.8m wide x 2m high, and 16m wide x 6m high.
We varied the distance from the sound source to the reflecting surface from 11 to 15m. From this distance, both the increased energy of the reflecting wave and the sound distance attenuation of the semi-free sound field can be obtained.
The measurement was taken with the microphone one meter from the sound source or double the distance from the reflecting surface. Sound propagation characteristics were determined for each receiving point.

## MEASUREMENT RESULTS

Figs. 3(a) and (b) indicate the measurement results for a wall surface of $52m^2$. The sound source is located 1.2m above the ground. The solid line in the figure is the theoretical distance attenuation curve (-6 dB/D.D) of the point sound source.

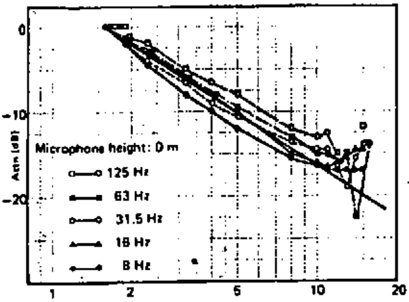


Fig. 3(a) Distance from the sound source (m)

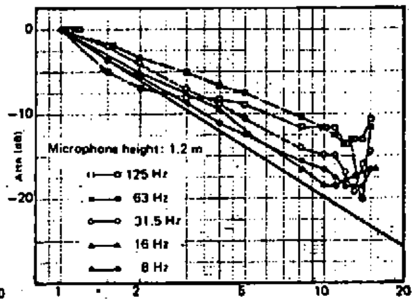


Fig. 3(b) Distance from the sound source (m)

Figs. 4(a) and (b) indicate the measurement results for a wall made for low frequency control experiment. The sound source is located on the ground.

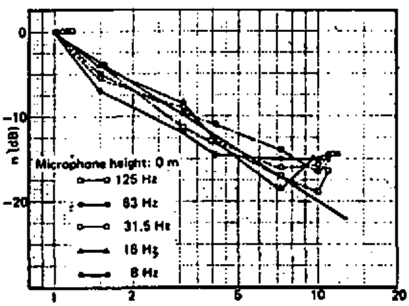


Fig. 4(a) Distance from the sound source (m)

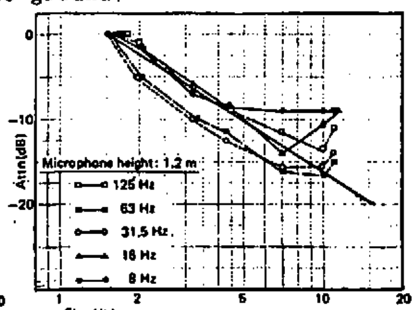


Fig. 4(b) Distance from the sound source (m)

## MEASUREMENT RESULTS SUMMARY

Sound attenuation varies greatly with receiving point height but is unaffected by the sound source location. Other experiments have confirmed that this is true when the low-frequency sound measurements are made in semi-free field or in obstacle-free outdoor locations.

(1) Even for a point sound source, the attenuation gradient decreases as the receiving point height increases.

When the microphone is set close to the ground, the attenuation is close to the -6 dB/D.D.curve. The experiment results compared favorably with the previous data on low frequency sound propagation characteristics. As the distance from the reflecting surface decreases, reflected wave influence increases until the results go off the sound propagation characteristic curve.

(2) The reflected sound intensity varies with the size of the reflecting object and the measurement frequency. The influence of a 7.6m reflecting wall is not very great in the 8 to 16 Hz 1/1 octave band noise. However, in frequencies over 31.5 Hz, interference from direct or reflected sound increases.

(3) Reflected-sound interference can be detected within 5m of the reflecting surface. There is little variation with microphone height. As the area of the wall surface increases, the receiving point must be located at least 5m from the reflecting surface in order to prevent reflecting sound interference.

(4) Accurate measurements cannot be made at distances greater than 10m due to wind influence, even if the sound pressure level is high. Even though the recordings were made with a band pass filter, the signal is unclear at 50m where there was no wind. By using a synchronizing-integral level meter in such cases, measurements 15 dB below the noise level can be made.

(5) From the above points, it became clear that effective low frequency measurement can be taken when microphone is located near the ground.

## CONCLUSION

Reflecting objects as little as 5 to 7m away influence low-frequency sound measurements. Sound pressure levels and interference increase in this range. The optimum measurement point is near the ground where measurements and ground reflection effects are stable.

The synchronizing-integral method is effective when the noise influence is large. At present, this method is being used to study low-frequency soundproofing efficiency.