CONTROLLED REFLECTION ISOLATION BOOTH

by Arthur Noxon • Presented at the 83rd AES Convention
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Summary

This studies the acoustic concept of introducing controlled room ambiance when recording sound samples, including vocals and musical instruments. The studies outlined here led to the ASC Quick Sound Field and associated recording techniques.

ABSTRACT

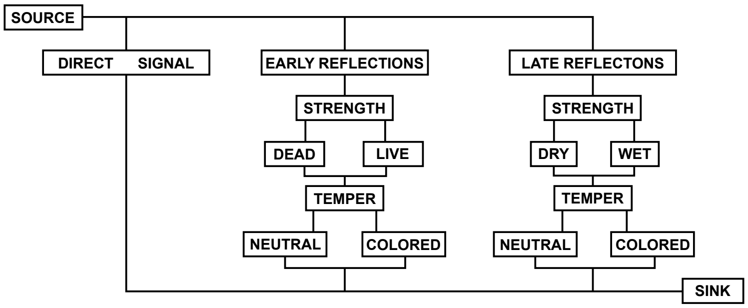
Sampling room design is of current interest. This is due to the influx of sample processors into the studio. The goal is to catch samples that are musically realistic. The question arises as to how short the sampling time window can be, what controls it and what is in it. Independent of the sampling problem, a studio mic technique was developed over three years ago. It is characterized by a strong liveness quality being added to an otherwise quite dry sound. Over the last year, sampling rooms have been designed and built using this acoustic technique, providing very satisfactory results. This paper presents the design strategy and acoustic signatures of recording rooms that have this “quick” sound quality and presents a case for its suitability as a sampling room.

PROLOGUE

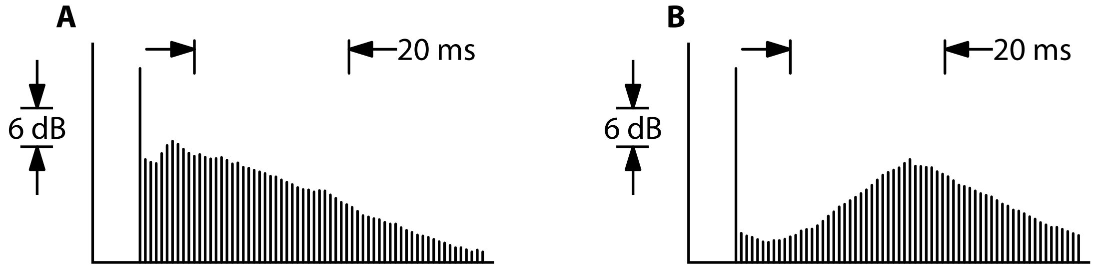
In the beginning, there is only one. Soon, the knowing few step forward, and eventually come the hordes. This is also the lifeline of each acoustical moment. We have the direct signal, soon followed by a set of early reflections, trailed by the multitudes in reverberation.

0.0 0.0 Introduction

The direct signal is received as it is sent. Both the early reflections and the reverberation will have distinct characteristics that are a function of the reflecting surfaces that support them. Each of these two reflection groups can be weak or strong. They may have temper, or spectral band pass characteristics. They each will also have a temporal or time-wise signature that describes their density and distribution of discrete signals including the decay rate. A flow diagram can be drawn outlining the multiple signal path options between the sound source and receiver. This outline is loaded with vocabulary that describes the quality of the sound options.



0.1 Early Reflections



There are two sides to the control room window. The recording studio produces the signal which then is mixed in the control room. Recording studios are very carefully set up to produce the proper composite balance between the direct, strong early and weak late reflections (1). The goal is to get a natural, realistic and full instrument sound onto a track suitable for the mix.

Control room standards require the engineer to hear the set of early reflections produced in the studio without distraction by the set of early reflections that belong to the control room (2). Its ambience is allowed after an initial time delay of 30ms.

0.1A and 0.1B show, at the risk of oversimplification, a comparison of the ETC (Energy Time Curve) of these two rooms, and that the handling early reflections is their major difference. The recording studio (A) emphasizes early reflections. The control room (B) suppresses them.

0.2 Recording Studio Rooms

Large recording studios with strong diffusive surfaces and fast decay rates are prescribed for accurate instrumental recording. They provide plenty of early reflections. The vocal booth and drum booth are other types of source rooms in the studio that have opposite natures. They are small and usually quite dead. In spite of themselves, they are often used as isolation rooms for instrumental recording.

0.3 The Sampling Room

The acoustic environs appropriate to a sampling room are at present ill defined. The traditional vocal booth approach is over damped, too dry. There are not enough early reflections to collect sufficient signals to develop a realistic sample. The musician also needs to hear the full sound of the instrument; such feedback is necessary in order to fine-tune voicing detail.

The acoustically bright and large studio produces reflections that are strong, easy to play to, but mainly too time delayed and initially too sparse. If sampling occurs in a small bright room, the early reflections may be soon enough, but risk being too strong and too colored with small room resonances. Such small room mic work is extremely position dependent; setup and repeatability are difficult and time consuming.

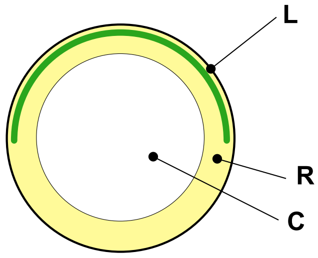
When the concept of diffusion is introduced, the time frame of 10ms for early reflection signals is the basis (3). Triple tonguing trumpet players in a concert hall produce audible dynamic transients whose duration is between 10ms and 20ms (4). Strong, dense and early reflections are necessary to accurately track musical transitions.

The apparent goal is to establish a small sampling room that has very fast decay rates, as does the small vocal room and drum booth, yet it must have a measure of very early, neutral and diffuse ambience, reminiscent of the larger recording studios. Rapid decay with rapid diffusion may well define the timewise signature appropriate to the sampling room. This will have the quality of being acoustically “quick,” i.e. live yet dry at the same time (5).

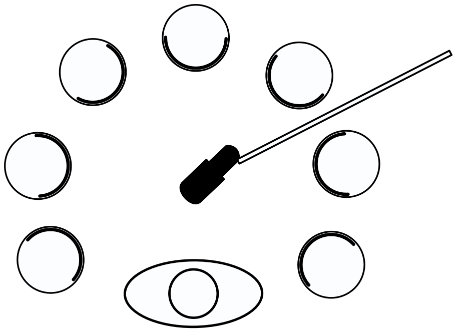
1.0 The Quick Sound Gobo, the “Acoustic Island”

A gobo technique was developed over three years ago that reduced the sluggish presence of the large recording studio ambience, while increasing the density of early reflections. A sense of liveness is developed in the signal. The original “Acoustic Island” gobo technique remains in use in numerous studios and is present here (6).

1.1 The Setup



The Acoustic Island utilizes a grouping of cylindrical sound absorbers called TUBE TRAPS.* A description of them will develop an understanding as to the reason for their use. An interior air volume (C) is surrounded by a dense fiberglass wall (R). This is a lumped parameter design whose acoustic RC time constant helps to access the low frequencies (7,8). About one half of the surface of this patented (9) trap is covered by a “limp mass” (L); it reflects mid and high frequency sound yet passes the lows for absorption.



The setup for the Acoustic Island gobo is in the form of a horseshoe pattern. Two 3 foot sound trap cylinders are connected together to form a column. Typically, seven columns are placed on a 2 foot radius centered about the mic. The reflectors of the traps are directed inward.

This gobo system performs two acoustic functions at the same time. The absorptive side of each trap faces the room, intercepting the sound of the room. This acoustic shadow zone feature develops 5dB isolation from room ambience. The second feature is by the reflectors. The direct signal is immediately followed by a dense fill of diffuse signals, strong in the first 10ms, which provides a boost of 4.7dB in the nearfield ambience. This immediate, dense and diffuse backfill is the voice of the QUICK SOUND FIELD (QSF)* effect.

*TUBE TRAPS and QSF are both registered trademarks of Acoustic Sciences Corp.

1.2 Gobo Testing

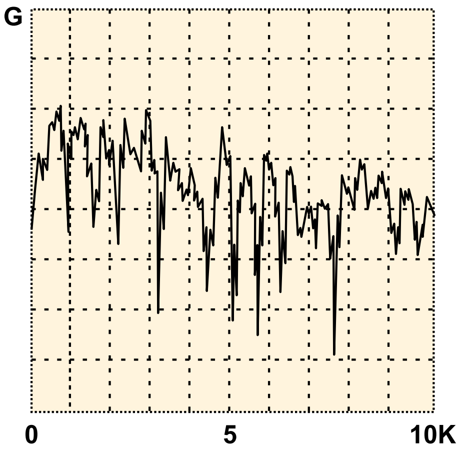
A typical vocal gobo was set up in a lightly treated, gyp board sound-testing room (8 x 14 x 18.5’). A “hot spot” speaker simulated the voice and 1/4” mic was positioned 2 feet away. The setup was 9 feet out from one corner with a patch of carpet below and some 1” fiberglass batt overhead.

1.2A and 1.2B (see below) are the ETC and waterfall taken in the room without a gobo. The ETC is 40ms, and the TEF (Time Energy Frequency) time ranges from 1 to 33ms. The ETC shows very few signals in the first 10ms compared to the second 10ms period. The direct to reverb energy ratio is 8.1dB with an early decay rate of 0.2 sec. Not the first 20ms has sparsely distributed returns. TEF waterfall (B) shows the room holding energy up through 5k, but notice the rapid shift from the full spectrum direct signal to the half spectrum set of room reflections.

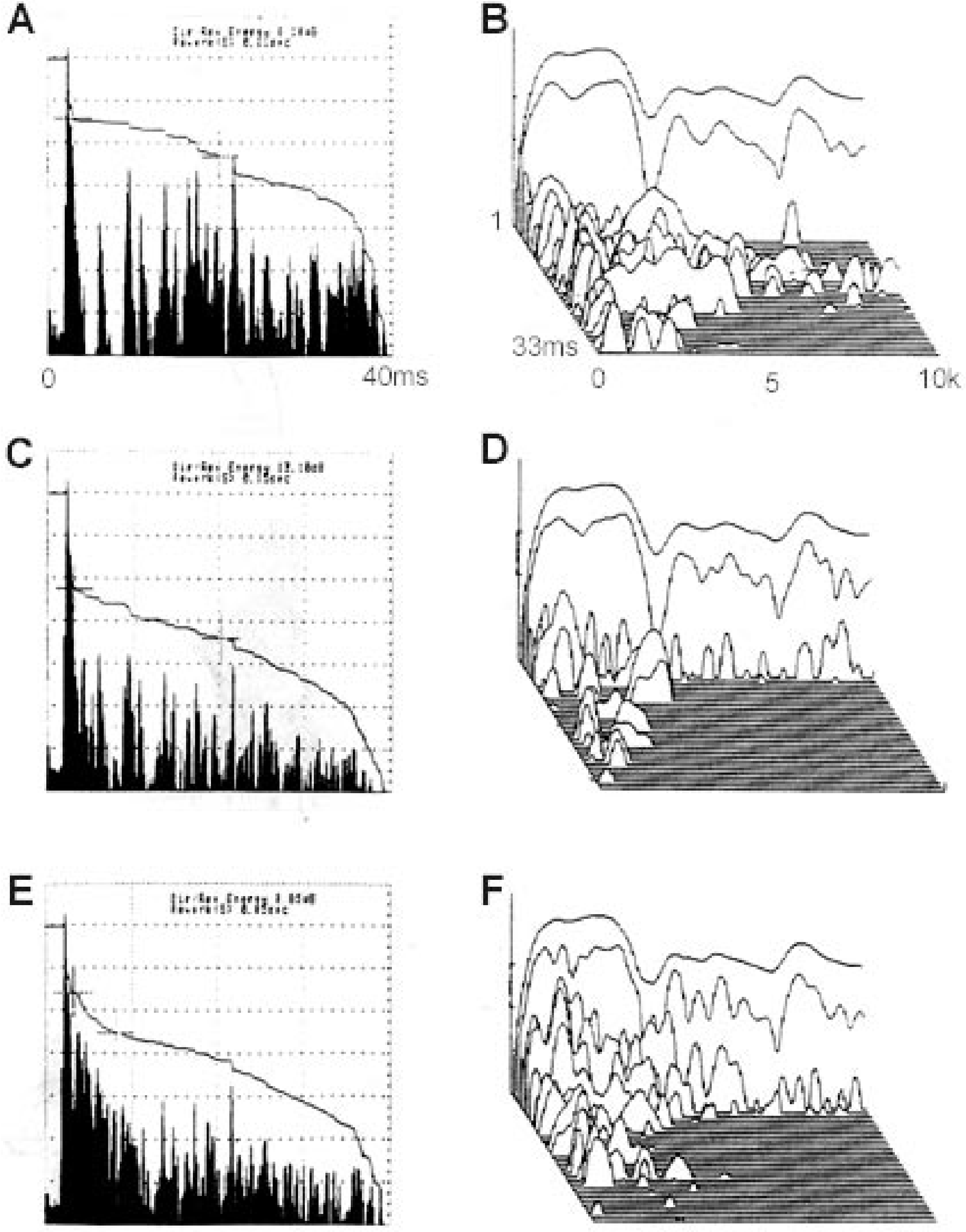
1.2C and 1.2D (see below) show the gobo setup but with the reflectors positioned to the outside. The room reverberant field is weakened, dir/rev ratio is 13.1dB, as the direct sound is absorbed by the traps. TEF waterfall and ETC both show some increased density of early reflections, due to the impedence discontinuity of the absorbers.

1.2E and 1.2F (see below) show the correct setup, reflectors toward the mic. Note the ETC, tremendous early reflection backfill. Direct/reverb ratio is 8.85dB, with an early decay rate of 0.05 sec. Reflections from the gobo immediately follow the direct signal for 10ms. The ETC has the classic QUICK SOUND FIELD signature, an immediate and strong backfill of diffuse energy lies just behind the direct signal. This feature establishes the “quick” quality of sound, giving it a lifelike, snappy presence.

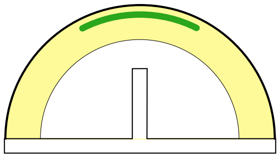
1.2G (right) shows the EFC (Energy Frequency Curve) of the early diffuse reflections, the backfill off of the reflections of the traps. A frequency sweep was taken at 5 1/3ms, only 3ms following the direct signal. This reflection is also visible in the waterfall of 1.2H. Frequency is linear in both. The neutral, broadband early diffuse reflections are clearly present.



A-F Acoustic Island Gobo Signatures

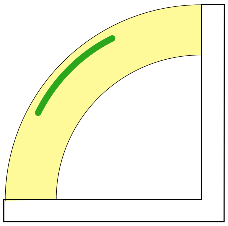


2 The QUICK SOUND FIELD Room



Success with the Acoustic Island gobo in the larger studio spaces led to an extension of the principles into the smaller, dedicated sound rooms, such as a vocal booth, drum room, broadcast voice-over rooms and the like, including the sampling room.

2.1 The Basics

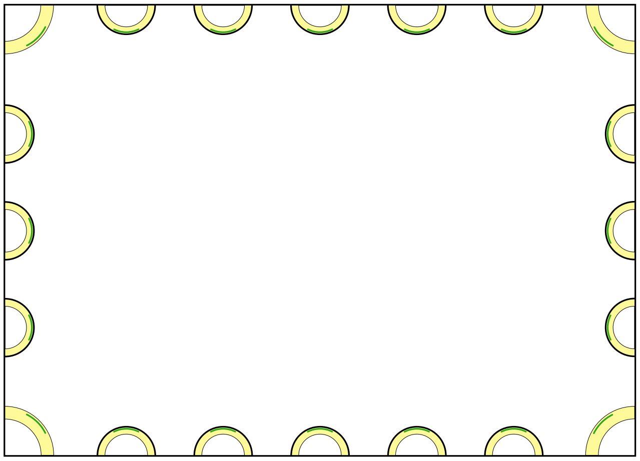


The acoustic devices utilized are the half and quarter round versions of the full round sound traps used in the gobo system. These segmented traps each have a reflector covering the central 1/3 to 1/2 of the surface of the trap. They are easily mounted in any position: horizontal, vertical or upside down. Their stiffness is due to a built-up-beam integral to the mechanically damped backboard structure.

The curved reflector in each trap serves to scatter midrange and high frequency sound. The lower frequencies are absorbed by the entire trap's surface. The lows are scattered not directly by the trap but by the process of diffraction as they rebound off the thin reflective wall strips between each trap. Dispersion of sound here is a two stage process.

Two types of walls have been built. A bare gyp boardroom can be outfitted with a set of traps on 18" centers. Another approach, initially used, is a freestanding isolation booth. It uses lead-backed traps with "tongue and groove" Plexiglas strips in between. That combination produces an STC (Sound Transmission Coefficient) of 32dB yet provides 30% visual contact with the outside.

2.2 The Setup



These 1/2 and 1/4 round TUBE TRAPS are typically on 18 inch centers on the walls and ceiling of a small gyp board sound room. Their orientation on the walls is vertical. Starting at the ceiling they'll often run all the way to the floor. This leaves a distribution of 6 to 7 inch wide strips of reflecting surfaces throughout the room. The ceiling is similarly set up.

The four wall/wall corners and the four wall/ceiling corners have the 1/4 round trap installed. This corner loaded trap has excellent absorption through 60Hz (10) and controls the lower frequency small room resonances (11, 12). Note the door and window are both covered with traps. As with the gobo system, visual access to the engineer or other players is maintained through the spaces between the traps.

The curved reflector in each trap serves to scatter mid and high frequency sound. The lower frequency range is not scattered by this specular reflection but by diffraction as the wavefront rebounds off the thin strips of hard wall surface left between the absorptive bodies of the traps. A more complete presentation of the performance of this unique class diffraction grating effect is presented in the addendum.

2.3 Vocal Test Setup

Here we look at the acoustic signature of a typical vocal setup in the QSF room. A full set of measurements is presented to develop an overall sense of the room’s performance.

2.3A illustrates the classic vocal setup used inside the QSF room. A small vocal hot spot speaker is positioned 14 inches away from the mic, some 5 feet off the floor. The mic/speaker center line is asymmetrically set in the room.

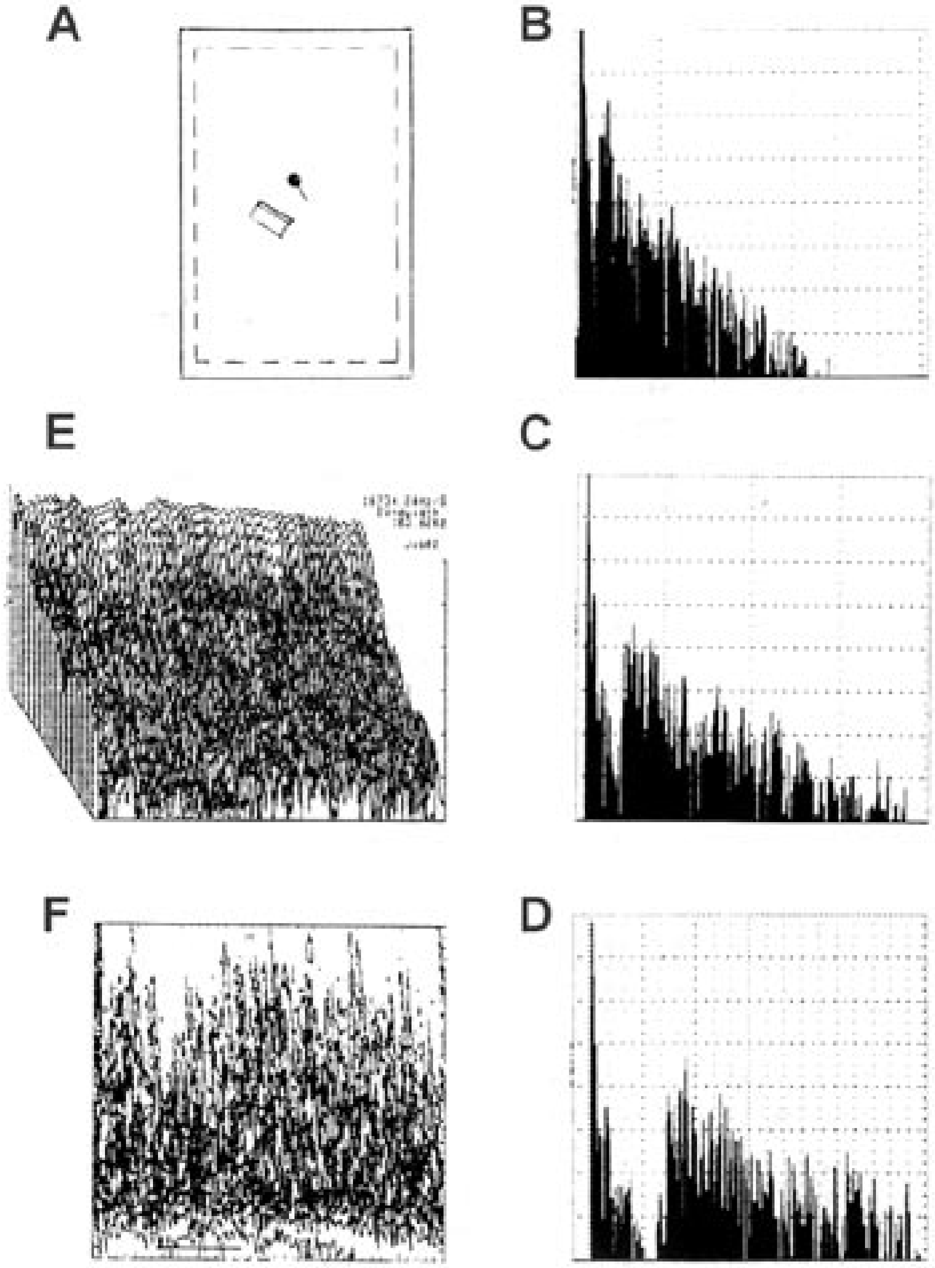
2.3B shows the 80ms ETC. At 6dB per division, the decay rate in the room is very steady, as evidenced by the flatness of the decay curve. Decay time, RT-60 is 0.11 sec. Except for the distinct 3ms gap between the direct and the first reflections, there are no spikes, no gaps, no time delayed kickers. The density of reflections is high and uniform.

2.3C retains the 6dB per division amplitude but has increased time resolution, only a 40ms ETC. The early decay rate is 0.09 seconds, just slightly faster than longer time averaged decay rate. The initial time gap is more evident. There is no loss in the smooth, dense fill of reflections that drop away in time.

2.3D shows the 20ms ETC at 6dB division. The regular features of the staccato of reflections continue to be observed. It is easy to count three significant reflections in almost any millisecond. The initial time gap is 42dB deep at 3ms after the direct signal. The subsequent diffusive fill begins at 4.5 ms, and each strike stays 24 to 30dB below the direct signal.

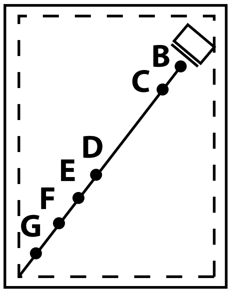
2.3E displays the 100 to 10K TEF waterfall over a 60ms period. The broadband smooth decay is obvious. The frequency axis is linear in this display. This type of decay in a small room is due to the balance struck between full range absorption and full range scattering. The vertical axis is 12dB/division.

2.3F shows the top view of the TDS waterfall. Again very regular, non-resonant decay is noted, evidenced by the high density of streaking straight down the time axis. Note the floor opens up at nearly the same moment, especially if the slight high frequency drop off by the speaker is taken into consideration.



2.4 Instrumental Setup

This series of ETC recordings was made with a sound source located 42 inches off the floor and 24 inches out from the face of a corner trap. The speaker faces across the room's diagonal. Test measurements are taken along the diagonal as indicated in 2.3A. All ETC data is in 6dB per division and 40ms.



2.4B shows ETC for 40ms with a close mic setup. The speaker/mic separation is 6 inches. A high density of diffuse fill slopes down from the direct signal. The direct to reverb energy is about 19dB. Reverb time is 0.09 sec.

2.4C shows the ETC for 40ms with the mic moved back to 18 inches. Note the direct/reverb energy ratio drops to 15.5dB. The RT60 remains at 0.09 sec. The early diffuse signature is still strong.

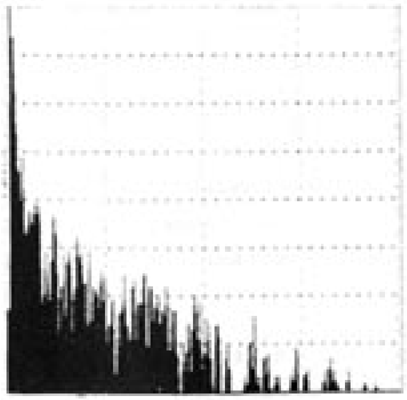
2.4D shows a mic distance of 54 inches. The direct/reverb energy is down to 7.76dB with reverb time to 0.08 sec. Notice the development of an initial time gap, it is about 5ms wide.

2.4E displays a mic position of 66 inches. The direct/reverb ratio is now down to 5.7dB, RT60 holding at 0.8 sec. The initial time gap is being reduced to about 2ms with a strong fill in the first 8ms. Each early reflection is within 14dB of the direct signal but their density is packing sound power into the early reflection time period.

2.4F shows mic position of 78 inches. Very strong ambience is developing. Count nine reflections 15 to 23dB below the direct signal within the first 6ms.

2.4G is the diagonal opposite the speaker, 90 inches apart. Count four distinct reflections between 10 and 15dB down, and within 3.5ms, and another group 6dB down in the following 3.5ms. This is very similar to the Acoustic Island gobo signature.

B



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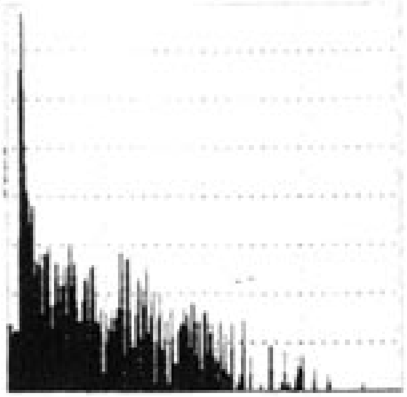

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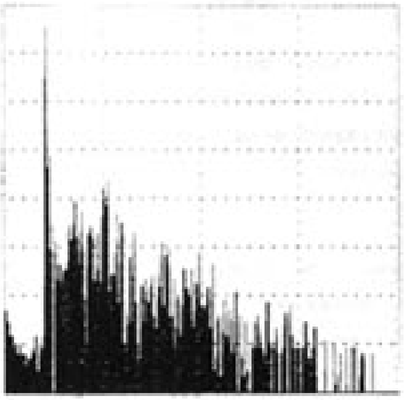

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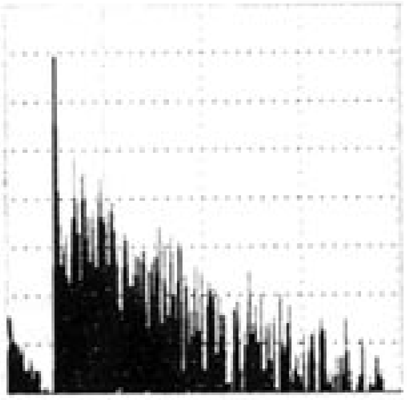

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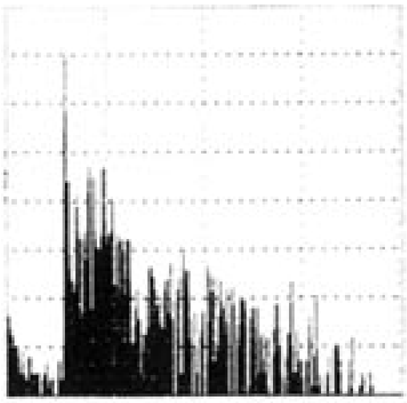

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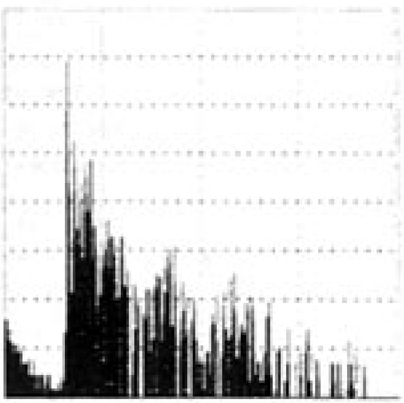
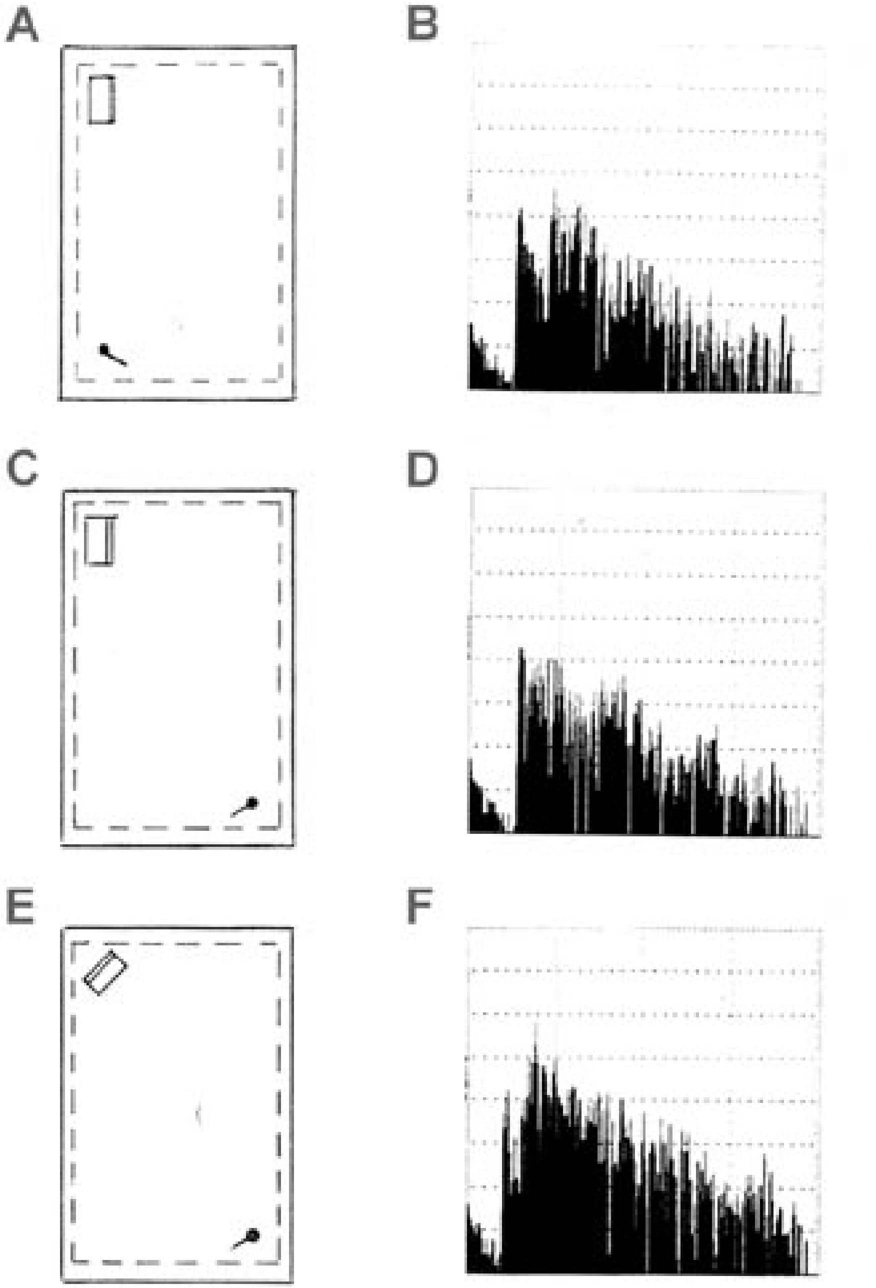


Throughout this survey of the room's acoustic performance, the decay rate in the room remained constant at .08 to .09 seconds. Nearfield and farfield mic positions had significant dir/rev ratio difference but otherwise had very similar, quickly dispersed sound fields.

2.5 Adjustable Setup



So far the ETCs presented are all variations of a strong direct signal immediately followed by a lower level set of diffuse reflections. As the mic moved back from the sound source, the dir/rev ratio was reduced. Additional adjustments to this ratio can be made. Here, the extreme case is reached where the direct signal is completely lost, leaving essentially only a pulse of diffuse signal.

2.5A and **2.5B** show respectively the setup and the ETC which it produced. ETC scales are still 6dB per division with a 40ms view of the time. The speaker is placed in one corner facing the opposite wall. The mic is placed some 72 inches away just off the same wall near the other corner. We have the direct signal now weakened, due to its directionality features, lower by a couple dB than the early reflections. This signature has an initial delay gap of 3ms followed by a 6ms slug of diffuse signals. By count, 16 separate reflections are within 3dB of the direct signal. It is reasonable to expect the lower, omni-directional frequency range comprises the direct signal while its full range is found in the early reflections.

2.5C and **2.5D** are similar setups, except the mic is in the diagonal corner. There is no initial time gap. The direct signal is immediately followed by 4ms of dense, equal level reflections (at least 8 by count) just 2dB down. Beyond that is a 10ms flood of signals just 6dB down from the direct. The mic, being more into the directivity pattern of the speaker, will show more midrange signals than the earlier setup.

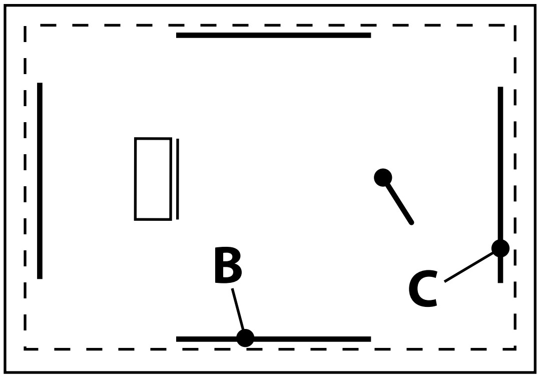
2.5E and **2.5F** show the extreme case of the direct signal being significantly below the diffuse early reflection group. The speaker faces into the corner and the mic is out in the open. The direct signal is easily 6dB below the peak of the early reflections. The early reflections remain stronger than the direct signal for over 12ms.

These setups are not necessarily being promoted. The desirability of their use rests within the ears of the engineer. The purpose served here is to illustrate in a first order manner how the QSF room handles off axis and directionality features of an instrument.

2.6 Real World Comparison

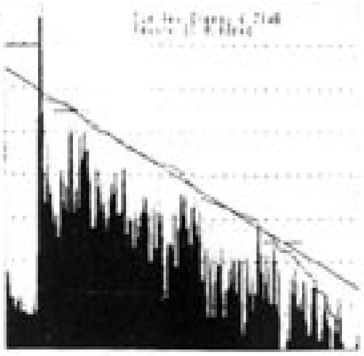
Information without a sense of reference is difficult to evaluate. The acoustical signature of the QSF type room needed a comparison. A series of tests were run that used approximately the same speaker/mic/room distances. By this, the distinctive feature of the QSF acoustical signature should become discernible. The speaker was generally 4 feet from the mic and both roughly centered in each room and 5 feet off the floor.

Three tests were taken in the QSF room, the first of which is the standard room. Then 2 sheets of plywood were installed to either side of the speaker/mic axis. The last test added two more sheets at either end of the room.



2.6A, 2.6B and **2.6C** show the three stages of the QSF room. One measured difference is the RT60. It starts at 0.08 seconds, extends to 0.09 seconds with two sheets and to 0.12 seconds with the 4 sheets. The second feature measured is the decrease in dir/rev energy ratio. There is 6.7dB in the QSF room, dropping to 4.07dB when 2 sheets of plywood are added and again to 2.44dB with four sheets.

A



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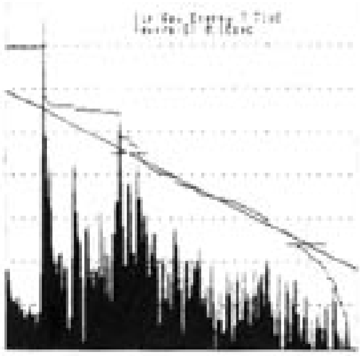

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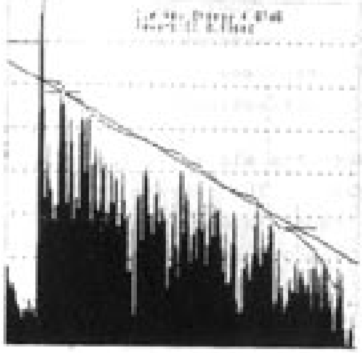

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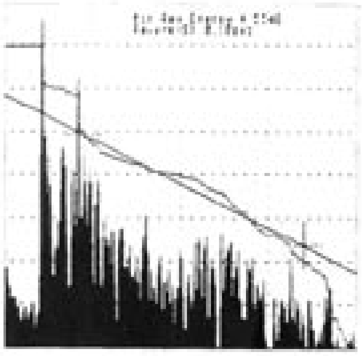

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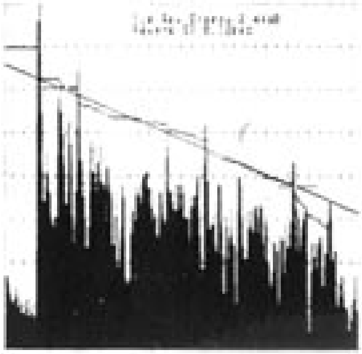

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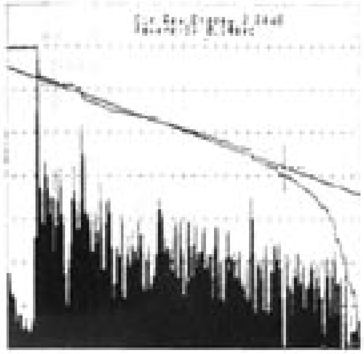


Subjectively, there are more “holes” in the ETC as plywood reflectors are added. There is also increased presence in sharp, strong spikes. Something more subtle is also visible, there are two parts to the bar graph ETC. The very dense, low level signals provide the solid, blacked out feature that seems to fill upwards from the bottom. Above this extremely dense signal set rises a series of distinguishable spikes. The more QSF the room is, the smaller and more frequent the spikes rise above the dense underfill. Weaker QSF rooms have their dense underfill cut into more often, the spikes become stronger and more separated.

2.6D, 2.6E and **2.6F** show a new recording studio, drum room and vocal booth room. Decay rates are respectively 0.10, 0.10, 0.14 seconds and di/rev ratios are 7.71, 4.55, and 2.20dB. The good dir/rev ratio of the studio is due to its size (15 x 20 x 8’). In all three cases, the diffuse substrait is heavily eroded and crowned with strong, clean and spikes. These rooms are typical and not very “quick” sounding.

3.0 Subjective Reports

A recording room has two clients, the performing talent and the recordist. Both need to be satisfied and their requirements are not necessarily the same. The QUICK SOUND FIELD room with its unusual lively/dead quality seems to satisfy both. Here are comments of impressions made by actual users of the QSF room.

3.1 Vocal: The first, immediate impression is its quality of silence. You hear nothing but what you are doing, no residual noise. It is easy to get feedback and immediately adjust for improvements. This room seems to be the ultimate practice room because it doesn't lie or make things more beautiful. It is an honest, clean, clear and yet dry room. The room is very comfortable to work in. I felt much sound all around me, and that is important, because in singing, I am so close to my instrument.

3.2 Cello: The cello in small rooms usually sounds muddy but not here. It has a natural, fat bottom-end. I heard the whole cello. Its sound came through the room clean, clear and comfortable.

3.3 French Horn: This room is impressive, dry and flat, not boomy but not dead. It seems very responsive to musical changes. A slight shift to emphasize upper partials really comes through and you can make immediate adjustments. I can hear a great deal, almost any detail, body movements, breathing, foot tap and fingering. It is an airtight room. I could hear all my imperfections which, while not fun, is good for me. For example, I thought I was ready for a demo tape with this piece until I had a session in this room. Now I know I need more work and no one had to tell me. Usually practice is hard because so much of the sound goes straight out the bell and I don't get to hear it. Here, sound is very good, gives the whole sound of the horn. When I played, I didn't feel like I had to hold back. It's a very comfortable room.

3.4 Drums: Usually the drum booth is too dead. Here, you can't tell you're in a small room. It's low and speaks very well. Sound is like a picture and this room takes an accurate one, good balance. Snare had a rounded, fat sound and I didn't have to doctor the heads. Playback was exact with what I heard live, usually coloration ruins it. Clear accurate sound of the whole drum is played by the room. That's what we want for sampling.

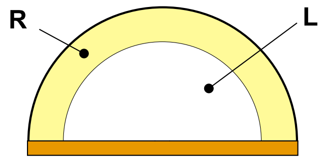
3.5 Recordist: The room is very interesting to work with, it is acoustically stable. I can move the mic anywhere and the room sound stays constant. It's a big plus to have this kind of stability in a small room. It's always hard to mic, placement and pattern selections are critical. Here I can make decisions based solely on the instrument and performer without concern for room color.

I used two mics on the French horn, one near and off axis while the other was set far across the room. There was no near wall reflection sound, no boom and no low end murky sound in the far field mic. The room saves the highs; I was able to get a good stereo pan between the two mic positions without seeing room color shifts.

Natural sound of the instrument is what I try to get. I often work in large halls and have to be 20 to 30 feet away to get the totality of the instrument. This room allows me to be just a few feet away and still collect the full sound without room color. This room does have strong ambience, but only of the instrument.

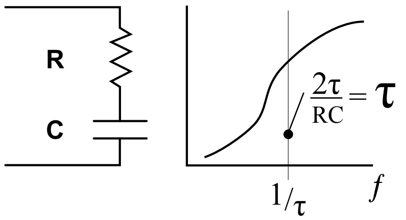
With drums, I usually close mic but here I could get 3 to 4 feet away from the mechanical noise. I usually roll off at 200Hz but here I can leave it fat and get the total drum sound, full, round and flat. I added reverb later and got a realistic concert hall snare. The bottom end is great. The room handles transients so well that they don't mask the attack of the "whomp." Hardstick on ride cymbals had fantastic ambience. I used only two mics on the snare, one 2 feet above and the other 2 feet below and to the side. I could mix very well, lots of isolation between the two signals.

ADDENDUM

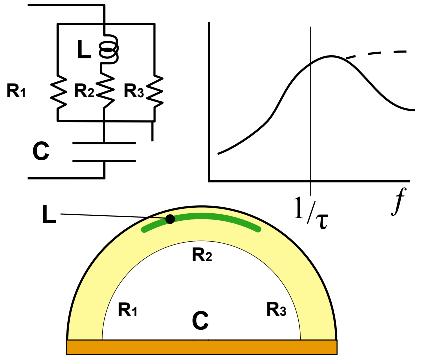


4.0 Absorptive Diffraction Grating

The scattering, diffusing action of distributed sound absorption has long been known (13). If absorbing or reflecting surfaces are in a regular pattern, the diffraction grating aspects of scattering are developed. Sound on a picket fence is split into two parts, one reflecting and the other transmitting. Both parts exhibit diffraction grating effects. The picket fence is a transmission type diffraction grating. If pickets are filled with a sound absorbing material, then only the reflective diffraction effect is developed. If instead the pickets are absorptive, then only the transmissive diffraction effects are observed. QSF rooms use the reflective component of the absorptive diffraction grating.

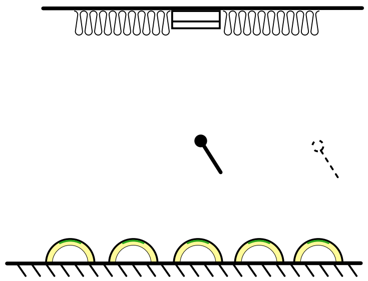


4.1 Lumped Parameter Absorption



The sound traps that have been used for diffraction wall work are 1/2 round, tubular shaped. Their interiors are hollow; their curved surface is of highly compressed, fine filament fiberglass. The acoustically resistive surface (R) in conjunction with interior volume (C) establish an effective RC acoustical circuit. This is a “high pass” sound absorber whose lower frequency cutoff is set by the value of the RC time constant.

In addition to the two lumped acoustic parameters R and C, each trap has a “limp mass” reflector (L) buried in its outer surface. Thirty to fifty percent of the trap’s surface is covered with this strip that reflects 400Hz and above. The strip is usually centered on the trap. High frequencies are reflected off the strip while the lows pass through it, to be absorbed.



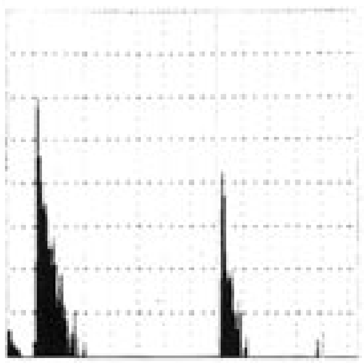
4.2 Diffraction Tests, Normal Incidence

A series of tests easily show the results of the distributed reflective and absorbing surfaces. A Techron-12 Frequency Sweep from 100 to 30K gives a 13ms Time Window, in which the ETC is taken.

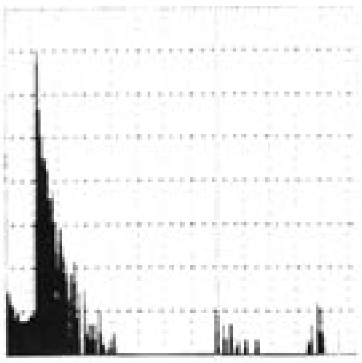
4.2A (above) Test Setup shows the speaker mounted to the ceiling of a testing room and surrounded with 6 inches of absorption to a radius of 3 feet. This damps the ceiling image to give a sharp spike delivery. The 1/4 inch mic is 4 feet above and parallel to the floor, the ceiling is 8 feet.

4.2B (right) shows the hard surface reflection. The floor return is nearly identical in timewise character to the direct signal, except that it is about 10dB lower in sound

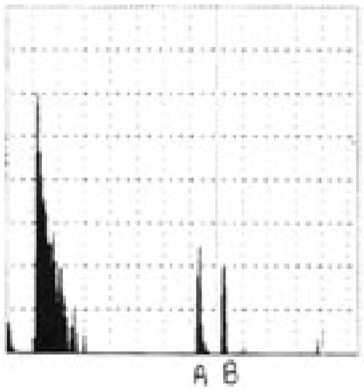
B



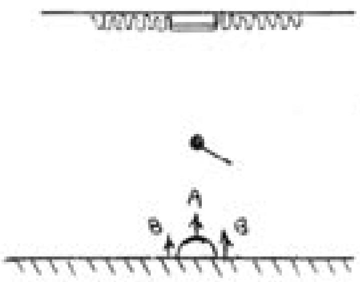
C



D



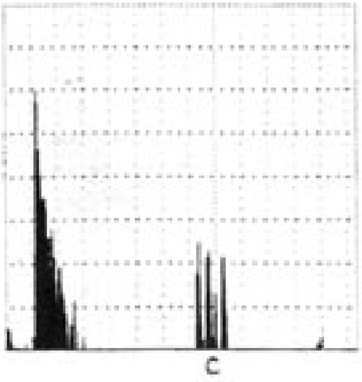
E



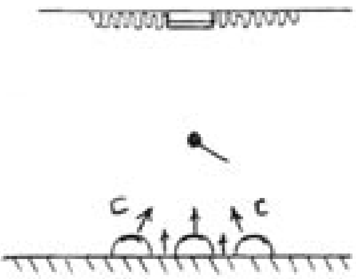
level. The direct signal passes by at 3.2ms and the floor bounce returns at 10.2ms. The ever present spike at 13.5 to 14ms is an extraneous reflection. The expanding point source wavefront accounts for a 20Log 12/4= 9.5dB reduction.

4.2C (previous page) shows the floor bounce modified by a 2” of “703.” The soft bounce is 27dB below the hard concrete reflection. This reflection is typical of the common flat wall absorption panels used in dead rooms.

F



G

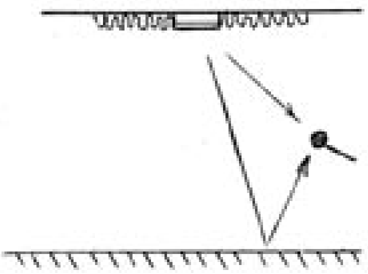


4.2D and **4.2E** (previous page) are for one trap below the speaker. Two reflections are seen. The first is 0.9ms ahead of the bare floor bounce and 10dB below it. The second is some 14dB below the floor bounce and delayed .01ms. The early signal (A) is a reflection off the limp mass diffusor surface. The delayed signal (B) is a reflection from the floor off either side of the trap. We see two dispersive actions, the first is specular from curved surface reflection and the second is diffractive from absorptive “edge effect” reflection.

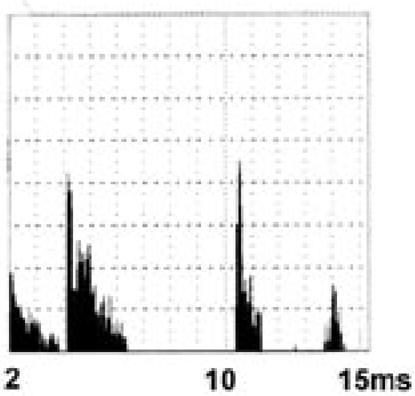
4.2F and **4.2G** (above) show two traps added to either side of the central one. Signals (A) and (B) remain undisturbed. Between them appears the reflection off limp mass diffuser panels (C) of the two new traps.

4.3 Diffraction Grating, Oblique Incidence

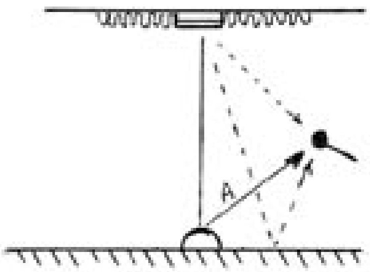
A



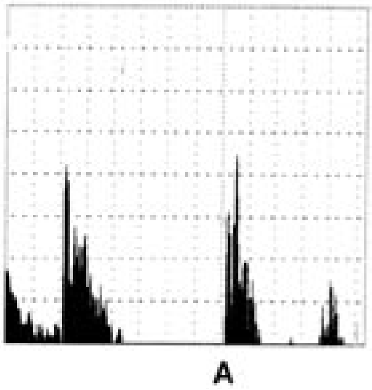
B



C



D



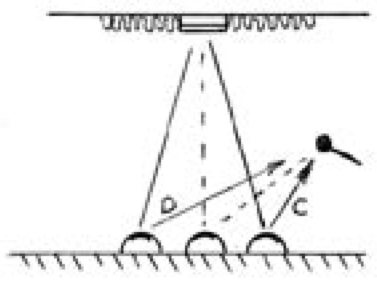
As the incident angle increases, the protruding absorptive trap blocks a larger percentage of the wavefront. Full absorption occurs at 30 degrees off the surface. This set of oblique incidence tests used the setup as before with the mic 3 feet to the side.

4.3A shows bare floor reflection to be 2dB above the direct signal. This is due to the directional beaming of the speaker. The direct signal (D) is at 4.2ms and the reflection (1) at 10.5ms, both larger than before due to the angles involved.

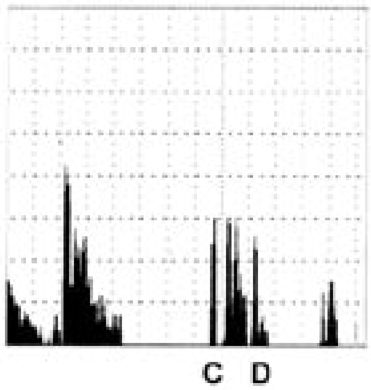
4.3B shows the effect of one trap placed directly below the speaker as in **4.2D**. The reflected signal (1) remains unchanged at 10.5ms because nothing was added where that reflection occurred. There is, however, an early signal (2) by about 0.3ms that is 9dB down. It is the acoustic glint off the sound scattering limp mass strip in the trap.

4.3C (previous page) shows the effect of two traps being added on 18 inch centers on either side of the first trap as in **4.2F**. The old floor bounce is now damped 9dB by the outer trap. Two new signals appear, one (3) is earlier than before at 9.7ms and the other later at 11.3ms. The first is the glint off the absorbing trap's limp mass diffuser surface. The second is a diffracting hard floor bounce off the edge of the traps. The reflection bends back into the shadow zone cast by the absorbing sound trap. Again additional traps make negligible difference to the signature.

E



F



4.4 Technical Discussion

The overall result of this diffraction grating technique is that the single sharp hard wall reflection is splintered into a set of 3 to 4 lower level reflections whose strength is about 10dB down. The splintered reflections are distributed out in time at 1/3 ms intervals and are within 3dB of each other. A balance has been struck in the dispersion of sound between the higher frequency, diffracting edge effects distributed absorption.

As a basis for comparison, recall the strength of a reflection off a 2" high density fiberglass. About 28dB of cut compared to the hard surface reflection is produced by this ever-so-common flat wall "acoustic treatment" for sound rooms.

The overall strength (Ld) of a multiple reflection signal is determined by the mean signal level (Lo), the number of signals level (Ln) and the fraction of time signal level (Lt).

Ld = Lo + Ln + Lt where Ln = 10LogN and Lt = 10Log (L1 + L2 + . . .) / T

The perpendicular reflection off a hard surface was split into three reflections (N=3) each some 12dB below the single hard surface reflection strength (Lo= -12). The time width of each reflection was 0.15ms, 0.2ms, and 0.15ms over a (T=1.2ms) period. The perceived strength of this composite is calculated:

Ld = - 12 + 10Log3 + 10Log((0.15 + 0.2 + 0.15) / 1.2) = - 12 + 4.2 – 3 = - 10.8dB

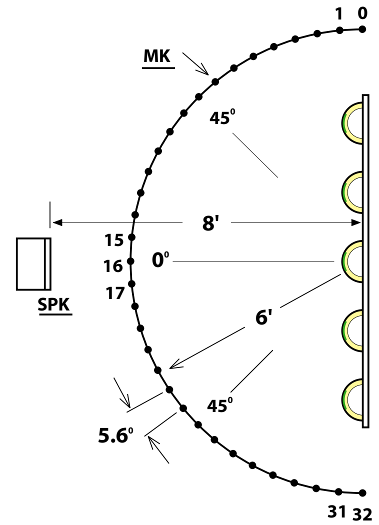
The diffraction grating reflection is 10.8dB down from the hardwall bounce. It is spread out in time by a factor of 10.

The oblique reflection off the grating produced 4 spikes each down 9dB and spread over a 1.8ms time smear. The discrete reflections are 0.2, 0.1, 0.1 and 0.15ms long. The resulting splintered reflection has a calculated level:

Ld = - 9 + 10Log4 + 10Log(0.2 + 0.1 + 0.15) / 1.8 = - 9 + 6 – 5.1 = - 8.1dB

The oblique, angled reflection off the absorption grating is down 8.1dB compared to the hard wall bounce and is spread out over time by a factor of 15.

5 Fresnel Diffraction Grating—Polar Plots



The most general diffraction grating is the Fresnel which allows for a spherical wavefront, the source being near the grating. A subclass is the Fraunhoffer diffraction, which requires parallel wave fronts. The absorptive diffraction gratings presented here are of the complex, Fresnel type. The sound source in small rooms is necessarily close to the diffraction grating and Fresnel diffraction occurs.

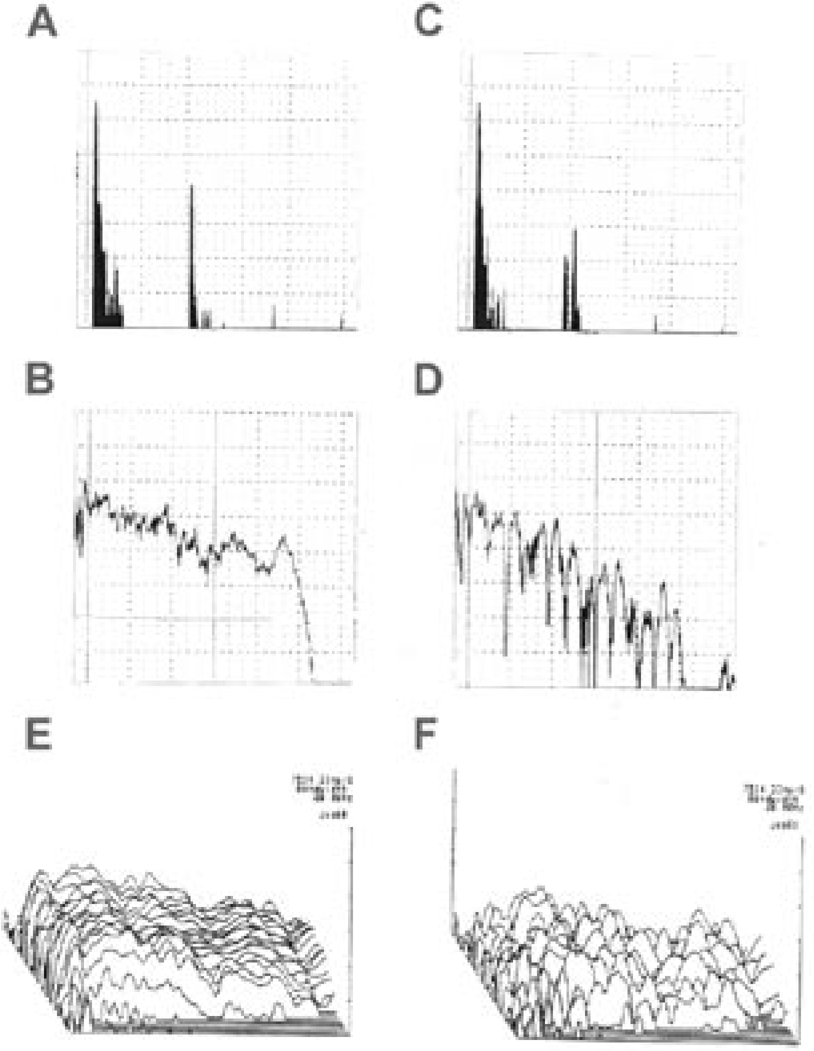
5.0A shows test positions for a 4 x 8 sheet of plywood in the open, with and without a grid of the 1/2 round sound traps. The speaker is at 8 feet and mic positions are every 5.6 degrees on a 5 foot radius about the center of the panel (14).

5.1 Test Setup and Measurements

5.1A and **5.1B** show the ETC and EFC (Energy Frequency Curve) of the flat panel for perpendicular reflection. The ETC is 6dB per division with a 30ms window. The reflection is 12 feet behind the direct signal and down 15dB, due of course to the expansion of the wavefront (the mic faces the panel, giving the reflection a small directional boost). The frequency scale (B) is linear, to see comb effects. An unimpressive, but realistic speaker frequency response is seen.

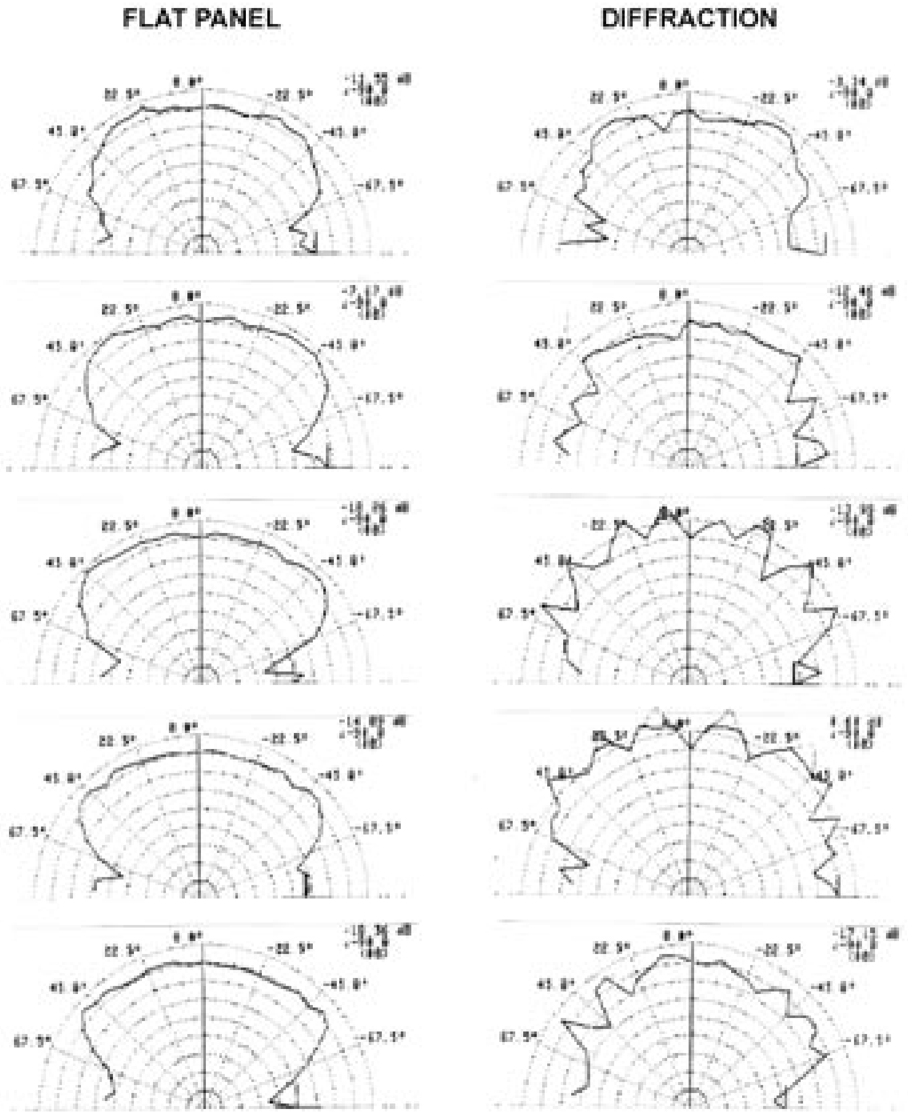
5.1C and **5.1D** show the diffraction grating effect. Notice the early double peak return off the reflectors of the center trap and the pair aside. The 1.1ms time difference between the first reflection and the surface reflection produces a 1/1.1 sec or 900Hz comb effect, characteristic of diffraction gratings.

5.1E and **5.1F** are the 32 frequency sweeps at 5.6 degree intervals that compare the smooth, specular reflection (E) with the very irregular, diffraction grid reflection (F), similar to that of 5.1D. The frequency sweep is 200 to 8K, linear scale. Throughout the angles measured, dramatic diffraction grating effects are obvious.



5.2 Polar Plots

The following is a set of polar plots taken at 5.6 degree intervals at specific frequencies. Data compares specular reflection to diffraction grating reflection of a spherical wavefront. Each plot is normalized to the strength of the reflection, perpendicular to the panel. Absolute levels are not displayed. The lobing near the 90 degree axis is erroneous, due to the direct signal leaking into the time window that is centered on the reflection.



Conclusion

We have illustrated methods by which a specific type of acoustic signature can be developed. It is characterized by the direct signal being immediately followed by a dense group of signals that rapidly decay out in time. This timewise signature is objectively distinct but that alone provides insufficient basis upon which to draw conclusions. The content of the trailing signal group remains to be resolved and its impact on the direct signal established.

The direct signal is a voice which can be colored by lower level signals that are both derived from the direct signal and received by the listener within 10ms following the direct signal. Reflected sound is obviously a signal derived from the incident sounds, correlation between the two is very high. The reflected signal may not have the same spectral content as the incident sound, depending on the absorption characteristics of the reflecting surface. The direct signal can be colored by spectral characteristics of its nearby reflections.

An instrument has directional properties in the sound field it produces. Its total sound is desired to be presented to the mic. Acoustical containment resulting in multiple reflections is a means by which the divergent components of the instrument’s sound field become redirected to pass by and be captured by the recording mic. In order for the multiple reflections to compliment and develop the voice of the instrument, they must fill the first 10ms time window. A small room is in order as the reflections are too time delayed in larger rooms.

There are two very different types of sound dispersive reflecting surfaces. The absorptive reflection method is signal coherent while the resonance reflection systems are signal incoherent. By definition the resonant reflection panels available today ought not to be able to faithfully develop the voice of an instrument. Both reflecting systems can produce comparable ETC records that look healthy but the quality of coherence or incoherence in the diffuse reflections is the issue. Incoherent diffuse early reflections should create distracting room ambience effects that mask the presence of the instrument’s voice. Collection of instrumental ambience requires retention of coherent, diffuse reflections that have good correlation to the direct signal. There remains both subjective and objective exploratory work to be done in the area of coherent vs. incoherent diffuse early reflections.

Epilogue

There once was a great singer who was accompanied by an excellent local choir. They were quite successful and hired an agent to schedule a world tour. This fella was very creative and decided the choir needed a more worldly air. He proceeded to thank, then discharge each of the local choir members. He replaced them with singers from many foreign countries. Each was to sing in their own native tongue. With this complete, the great singer and his newly formed entourage left on tour. They were know as the “Choir of Babbel” and were never heard of again.

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