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BY ARTHUR NOXON

Trapping Bass in Your Project Studio

Sound is acoustic energy and rooms store this energy. Resonance is nature's most efficient way to store acoustic energy in a room. Resonant energy easily lasts two times longer than sounds that are not resonant, and this is how the coloration of sound occurs in small rooms.

AN ALL-CONCRETE REVERBeration chamber can store sound for at least ten seconds, an empty gymnasium is good for five seconds, and an empty room in a house has a decay time of two seconds. In pro or semi-pro audio rooms, a decay time of no more than 1/2 second is preferred. The typical furnished but untreated residential-type room has decay times of 1 ¼ seconds. So, serious audio rooms need serious acoustic treatment. Midrange and high frequency sound is easily absorbed, but the lows are problematic. Sound absorbers that handle the lower octaves are called bass traps.

ROOM RESONANCE

Almost everyone can read about "room acoustics," which actually discusses the midrange and high frequency, the upper three octaves of the keyboard. Now, the domain of low frequency acoustics in small rooms is to be explored. This article will provide an overview of the theory, history and practice of bass trapping with an eye towards home and project studios.

Without proper decay times, mic work or listening in an audio room is hampered by excessive reverberation. Resonances color the acoustic signature because they are a group of specific tones that overhang longer than the others. Excessively sustained overtones cover over, blur and mask out the low level musical inner detail. The control of decay times in the audio room means controlling the resonances, and giving the room a neutral voice.

Resonant frequencies are not always the same; they will vary depending on speaker position. With a walking, talking person, the position of the sound source changes, stimulating different resonances. The loudspeaker however, is fixed in position. It stimulates the same group of resonances over and over again, The coloration is fixed; it penetrates and stains all recorded and playback material. Instead of capturing the "infinity" of musical variations that create evanescent luster in audio recordings, resonance forces a redundant tonal emphasis which renders music essentially boring–no matter how much talent is applied.

Electronic upgrades in the studio should develop enhanced performance. The need for any improvement springs from some dissatisfaction with the present system. The room acoustic is the first and last link in the audio chain. It is staggering to consider how many pieces of electronic gear have been purchased out of frustration with a system whose real problem was not electronic at all, but was driven by the colorations due to room resonance.

There are only two ways to get residual low frequency sound energy out of a room. The first and most common is leakage. Unlike the downtown recording studio, deep bass leaks out of most home and apartment construction. Leakage paths can be direct transmissions through the walls, ceiling, floor, doors and windows. The heavier the surface, the less leaky it becomes. Other leakage paths are through openings such as under the door.

Absorption is the second method by which acoustic energy is removed from a room. Downtown recording studios are heavy-walled and sealed airtight to keep unwanted sound out. This is called isolation. If sound is kept out, it is also kept in, and so studio builders have developed a variety of low frequency sound absorbing techniques. Hopefully, most of these will be reviewed in this article. The designer/contractor-built studios usually have bass traps built in. The rapid expansion of MIDI equipment has resulted in many serious home-based project studios that are virtually without acoustic control.

The single most important result in a properly bass-trapped room is that it has more bass, deeper punch and smoother extension. This sounds contradictory–that bass trapping a room gives more and not less bass. Actually, what you get is the bass you always had; you just could not hear it because the resonant colorations covered it.

Once the basic concepts of room resonance and bass traps are developed, the practical matter of setting up a room needs to be discussed. This is broken into two sections. Trapping the front or driven end of the room requires special considerations because of its proximity to the loudspeakers. The back of the room is more intuitively obvious and belongs to the world of deep bass traps.

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Virtually every downtown recording studio uses some type of bass trap to control distortion and coloration of the frequency response in the room due to low-end build-up. Bass traps in these studios can be found hidden above the ceiling, inside the walls, below the floor and sometimes even in adjacent rooms. The nagging problem for home and project studios is that most engineers cannot consider contractor renovations as an option for an acoustic upgrade of their living rooms.

ROOM ACOUSTIC BASICS

Before considering bass traps in detail, a review of acoustics is in order. This will develop a sense of perspective and scale. The behavior of sound waves and objects depends on the size of the wavelength, in comparison to the size of the object. Simply put, long wavelengths go *around* small things and small wavelengths get *reflected* by big things.

The wavelength of a sound is mathematically related to its frequency or tone. The higher the frequency, the shorter the wavelength. Our range of hearing officially spans ten octaves from 20 Hz to 20 kHz and we can perceive or feel sound even below 20 Hz. (1 kHz = 1,000 Hz of cycles per second.) An octave is the doubling of frequency: 20 Hz, 40 Hz, 80 Hz, and so on. For audio playback in small rooms, bass is considered to be the first four octaves (20 Hz to 320 Hz); mids comprise the next two (640 Hz to 5.12 kHz); and the highs occupy the last four octaves. Sounds of the piano keyboard are familiar to most of us; middle-C is a frequency of 256 Hz. The bass range on a piano occupies more than half of the piano keyboard, and about forty percent of the full auditory spectrum.

Bass wavelengths are similar in size to the room in which they exist. It's easy to calculate the size of a wavelength from the formula: wavelength n_\ = speed of sound (c) /frequency (f). By comparing sound wavelengths to the size of a house, the size of bass wavelengths are evident.

The shortest "bass" note–A440–has a wavelength of about 2.5 feet. The longest wavelength is 56 feet, and it belongs to 20 Hz.

Full range speakers generally produce sound extending down through most of the lower end of the piano keyboard. Subwoofers produce sound specifically in the last octave of the piano's keyboard and the one just below it, the first audible octave.

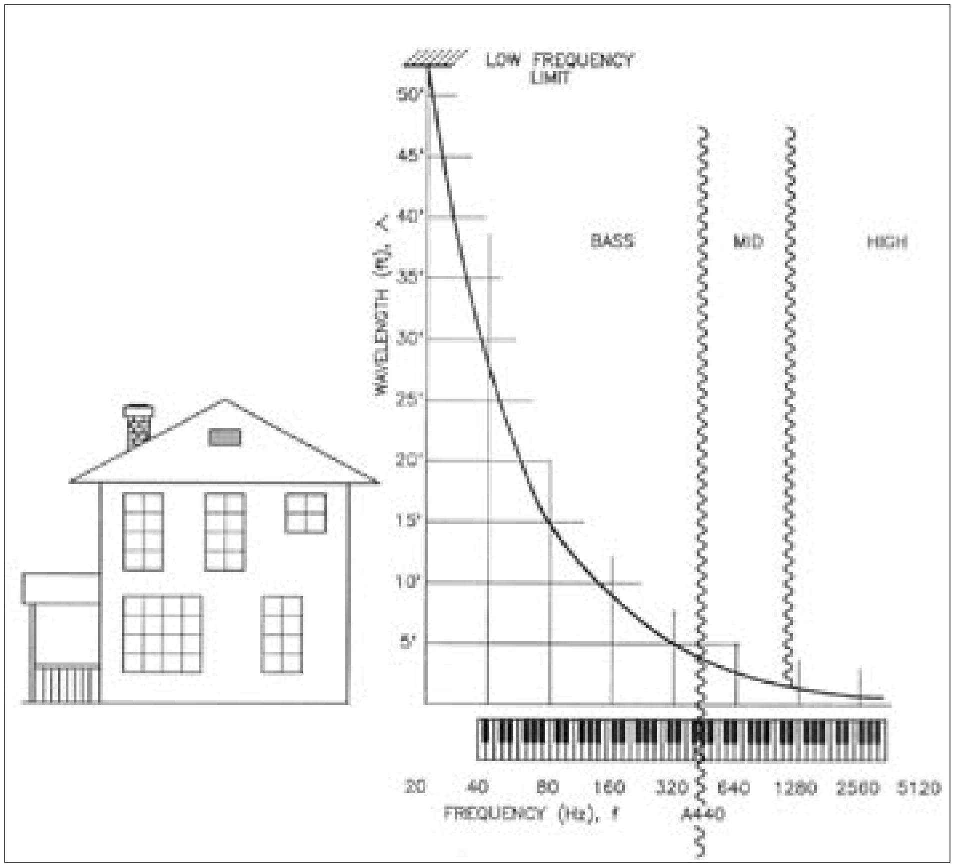


Figure 2. Wavelengths of sound.

Figure 1. The keyboard and the audio spectrum.

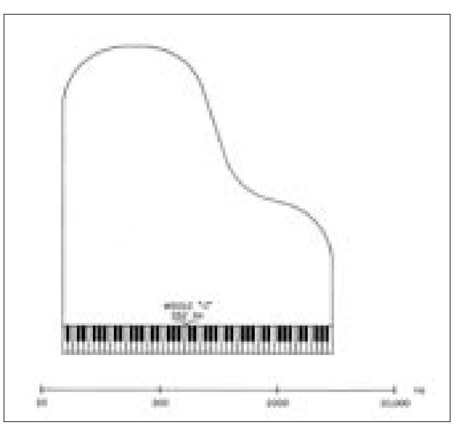
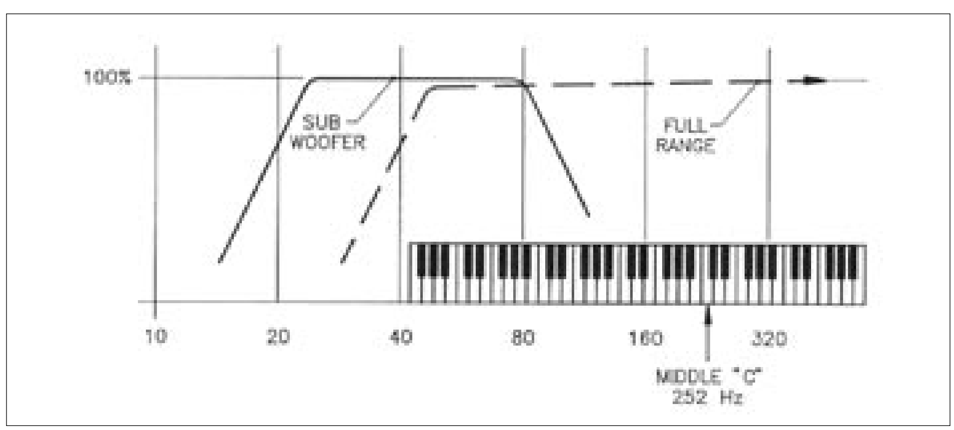


Figure 3. Loudspeakers and low-end rolloff.



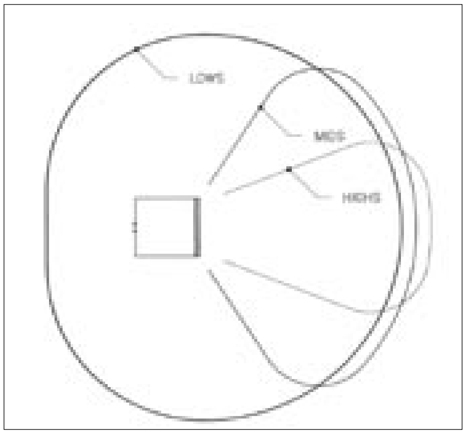


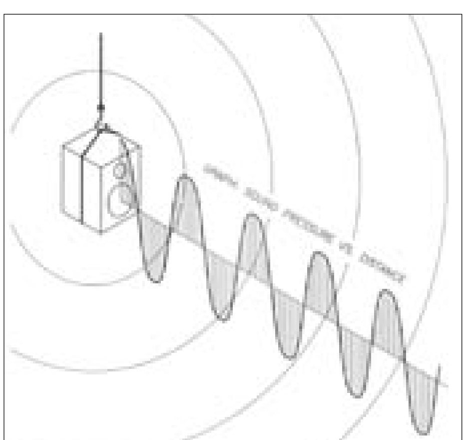
Figure 4. The directionality of speakers.

SPEAKER DIRECTIVITY

Speakers possess frequency-dependent directional qualities. For both mids and highs they produce adequate sound levels only in the forward direction towards the listener. Lower frequencies from the same speakers, however, radiate equally in all directions. This directionality means that mids and highs are efficiently beamed towards the listener, and little acoustic energy is wasted on illuminating the rest of the room.

The lows easily require six or more times the acoustic/electric power than the mids and highs to achieve the same sound level at the listener's position. Speaker efficiency is one reason for power gulping; the other is directionality. Because bass waves are bigger than the speaker, they travel with equal strength in all directions. The speaker is an "omni" pattern sound source. Often much of the bass wavefront has bounced off of the walls, floor and ceiling of the room before it even reaches the listener.

Figure 5. Wavefronts and wavelength.



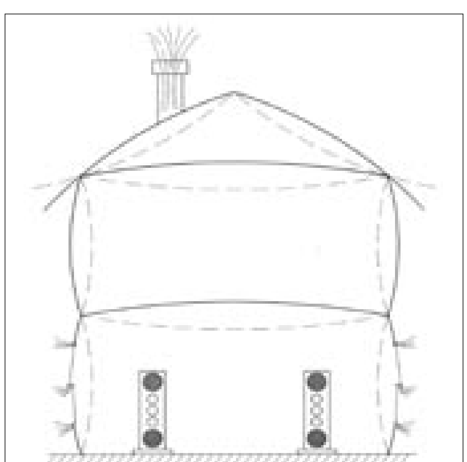
Sound is an airborne ripple or wave whose speed (c) is about 1,128 ft/second. Consider the piston of a loudspeaker that is vibrating to and fro at 100 Hz. In the exact amount of time it takes for the speaker cone to make one cycle, or complete a round trip (1/100 second), the sound wavefront it generated will have moved away from the speaker (1/100 x 1128) some 11.28 feet. For a continuous tone, this becomes a repeating event. As you move away from the speaker, every 11.28 feet would be the same acoustic condition.

THE BREATHING MODE

This review of small-room acoustics begins with the lowest octave. Here, the wavelength is quite long as compared to the size of the playback room. The room as a whole experiences internal pressure changes. Acoustic activity in this region below the room's so-called "cut-off frequency" remains quite audible. Here the speaker is acting on the room as if it were a pneumatic plunger, alternating between pressurizing it and pulling a partial vacuum on it. The walls, floor and ceiling react to what seems to be a rapidly changing "barometric" pressure in the room. Room surfaces billow out and then cave in with each cycle.

Major structural resonances are easily stimulated by breathing mode acoustics, a common problem in playback for the larger power systems of today. The surfaces of the room simply shudder in the bottom end as the speakers stimulate, then overpower the mechanical stability of the room. The result at high sound levels is a total loss of control for low-frequency musical reproduction, as if sound in the room "crumbles" when it is overloaded. This LF breakup of the room itself is particularly evident in the concussive punch bass beat attack transient.

Figure 6. Deep bass – breathing mode.



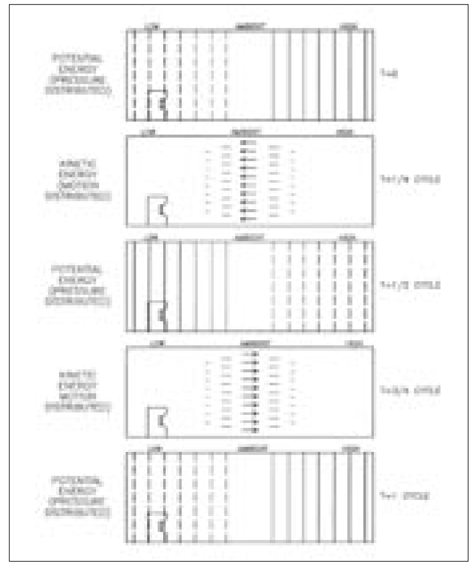
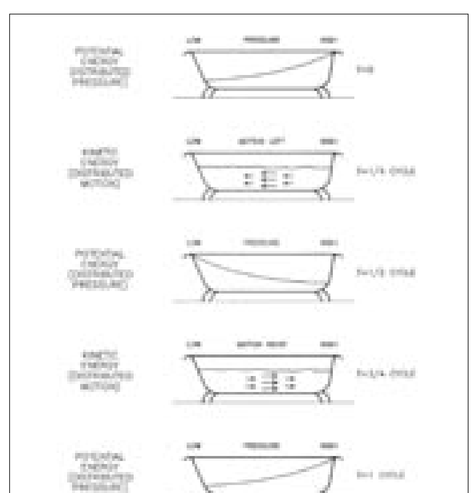


Figure 7. 1st room resonance (1,0,0).

ROOM MODES

As the tone from the speaker is raised in pitch, out of the deep bass octave and into the piano's first bass octave (40-80 Hz), a new class of room acoustics develops, called Room Resonant

Figure 8. Bathtub mode (1,0,0).

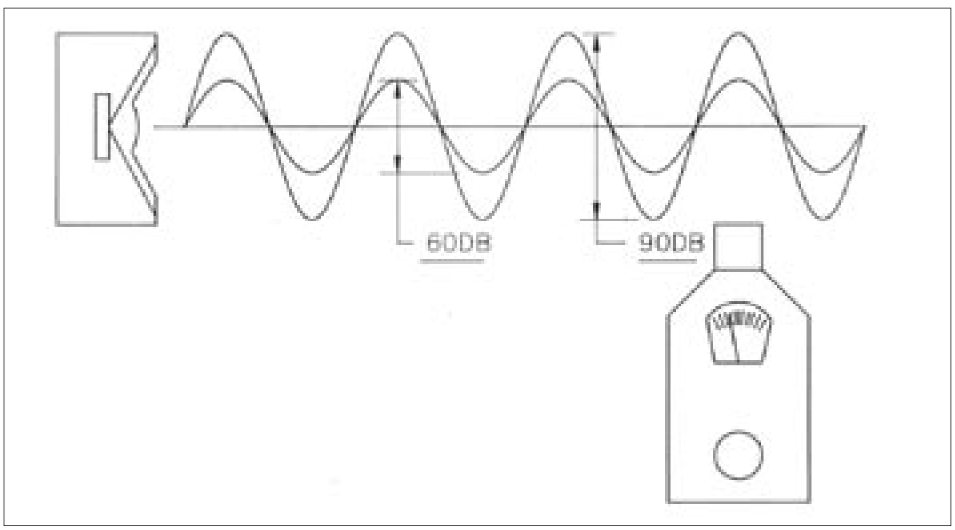


Modes. The lowest frequency at which this can occur is called the long dimension axial (1,0,0) mode.

The fundamental room resonance is easily stimulated when the speaker is located at one end of the room and the wavelength of the tone played happens to be twice as long as the room. The wave from the speaker travels down the room only to bounce off the rear wall and return to the front of the room. During this time the speaker makes one full cycle of motion itself. It generates a tone exactly in step (or in phase) with its reflection. These two waves–the old reflected wave and the new one–add together exactly, without confusion. After a number of cycles the sound levels build, enveloping the room in resonance.

For a non-resonant tone, sound builds up in the room in highly disorganized manner. With resonance, however, the air is stimulated into a "sloshing" mode of behavior, not too unlike what can happen with a child in the bathtub if their to and fro movement happens to keep time with the water's natural end-to-end slosh motion, called first harmonic.

Figure 9. Sound and the use of an spl meter.



MEASURING RESONANCE

It is interesting to explore acoustic resonance with a SPL meter. Such a meter is very useful, can be found at stores like Radio Shack, and cost as little as $30.00. You can also use a mic patched into your board, keeping an eye on the VU meter.

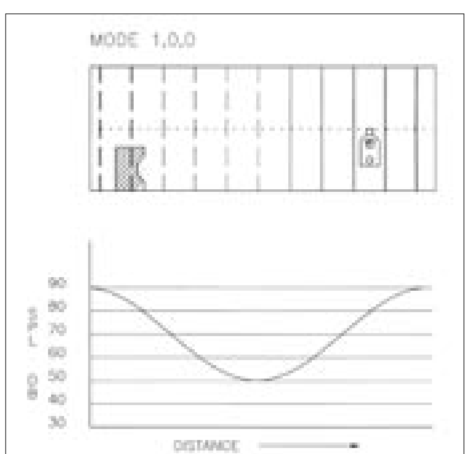
Sound meters measure the strength of "sound pressure changes." If the SPL meter reads 90 dB, that means the air pressure at the microphone is fluctuating strongly above and below ambient air pressure with a strength of 90 dB. Compare this to a 60 dB reading and notice that the fluctuations in pressure are much smaller and the sound is quieter.

By the way, dB, A is not a flat response curve. It is rolled off gradually below 1 k as our own hearing response does. The dB, C scale is "flat" for most purposes. A mic, patched through without equalization will be close to dB, C levels, not dB, A levels. The dB, C or flat response weighting is best for room acoustic measurements and the mic should be an omni mic.

If the mic or SPL meter is moved from one end to the other end of a room that is in the fundamental mode of resonance, data points can be taken and plotted against position. High SPLs are detected at both ends of the room, and a low SPL in the middle. These are known in audio as "hot" and "cold" spots; the "hot spot" is where pressure changes strongly occur and the "cold spot" is a location where pressure only slightly changes.

Just because we don't hear sound in the cold spot doesn't mean the acoustic energy is gone. The sound may be "cancelled," but the kinetic part of acoustic energy is in full presence. Although we can't hear acoustic kinetic energy, a ribbon mic properly oriented can pick it up. Note that the same ribbon mic in a pressure zone will not register any sound. This is because ribbon mics pick up the air motion of sound while condenser mics pick up the air pressure of sound. For a ribbon mic to pick up the acoustic kinetic energy, it must be aligned per indicator to the direction of air motion.

Figure 10. Sound level distribution.



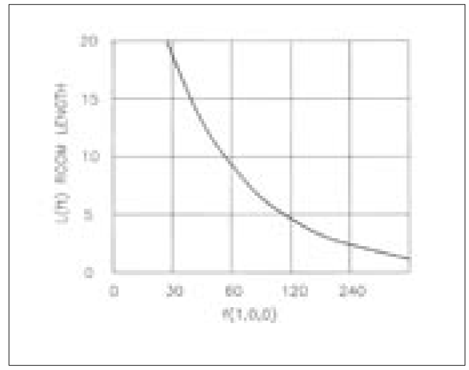
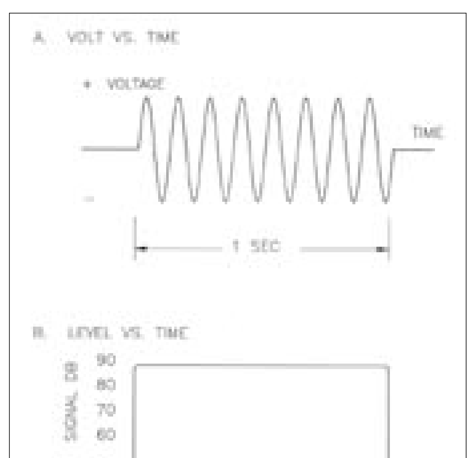


Figure 11. Lowest resonance frequency.

Figure 12. The tone burst.



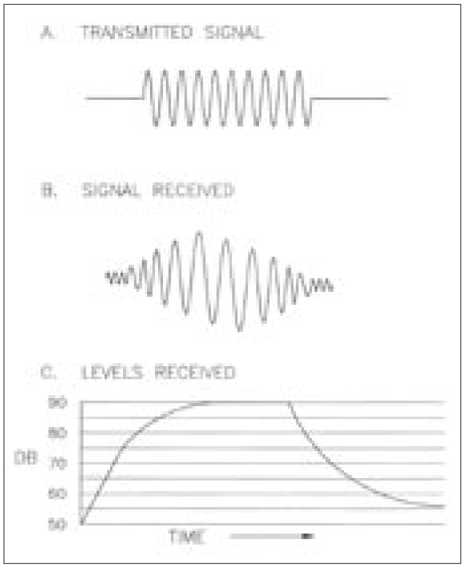


Figure 13. Burst in a room (end).

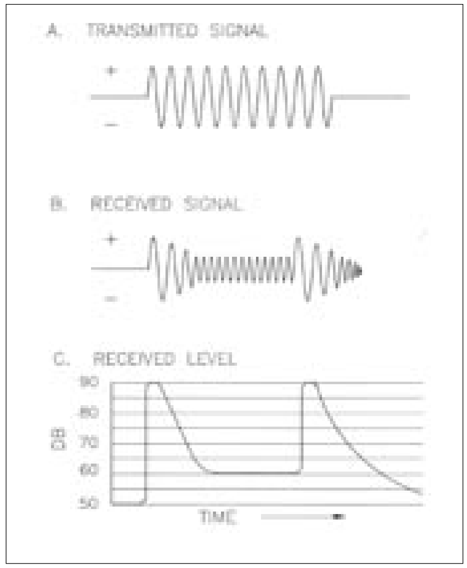


Figure 14. Burst in a room (middle).

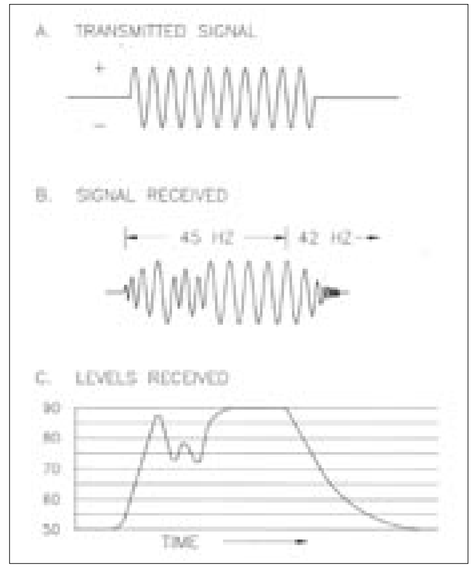


Figure 15. Resonance coloration.

If rotated ninety degrees so the plane of the ribbon is aligned with the direction of the acoustic kinetic energy motion, the mic will not give a reading.

The frequency of the lowest room resonance (1,0,0) is easy to calculate from f100 = C/2L. Measure the length (L) of your room and use the equation to calculate the room's fundamental resonant frequency. The graph of the equation is also useful to use.

LISTENING TO RESONANCE

The size, shape and internal details of a simple room will affect its resonance frequencies. By using a f100 tone burst, lasting about one second, as a test signal and feeding it to a speaker, we can watch the SPL meter to illustrate overall frequency response of the room. By listening first to the burst over headphones and then again while using the room as an acoustic coupler, a very clear audition of room acoustic resonance effects can be heard.

This kind of test, called a MTF (Modulation Transfer Function) test, is the basis for checking the quality of any communications channel. The Studio Reference Disk by Prosonus (list $69.95) has this test on track 50. MTF testing is the more full bandwidth, musical cousin to speech intelligibility tests that sound contractors are wrestling with these days.

The "Hot" f100 location to illustrate the presence of excessive reverberation is at the back wall of the room. Here one hears the slow "turn on," excessively high sound levels, and a sluggish "turn off" response characteristic. The sound of the tone burst sound is not sharp, but "blooms" and "fades." This can be characterized as the difference between the test "boop" sound and the "moo" sound delivered to the listening position. The fact that a distinct, sharp signal is not really heard is clear evidence that it is the *room* we are listening to and not, as we usually presume, the *speaker*!

What we hear, in fact, is the gradual build-up of energy in the room as the speaker begins to move or slosh the air in the room. With each cycle of continuous tone, the sound level continues to build, but only until the power being pumped into the room by the speaker exactly equals that being lost and dissipated by friction and leakage. Only then can a steady-state sound level be reached.

When the speaker quits vibrating, the sound does not just simply stop. There is built-up and stored acoustic energy in the room which requires time to damp out. Acoustic friction reduces the energy of sound in the room, as does the leaking of sound out through windows, doors and the walls. It's the leaking part that neighbors will comment on.

SOUND "CANCELLING," THE COLD SPOT

When sitting about the middle of the room at the "cold spot" while the first resonance is set up, the very curious effect of "sound cancelling" occurs. Here, the sound from the speaker is exactly out of phase with that of the room resonance at that location. Sound pressure may be cancelled, but nature does not give up so easily; acoustic energy is not cancelled. If sound (acoustic pressure) is "cancelled" in one part of the room, it has only been replaced with acoustic kinetic. Conversely, sound pressure will be found substantially louder elsewhere in the room at locations that have been stripped of acoustic kinetic. Acoustic energy is an interplay of acoustic pressure and acoustic kinetic. Ocean waves have a similar action–the water wave has height (pressure) and motion (kinetic) energy.

When we audition the one second tone burst here, we first hear clearly the initial sound from the speaker. But it becomes quieted as the buildup of the resonance in the room reaches full strength and cancels the direct sound at the listening position. When the speaker is turned off, suddenly we hear the sound of the reverberant field as it decays. The response of the burst is not the clean, crisp "boop" sound. It is more like a "bow-wow."

In either case, and depending where one sits, the in phase or out of phase room resonance/speaker coupling effects dramatically rewrites musical dynamics and intonation. This illustrates why the engineer can hear magic and the producer on the talent couch still thinks it needs work–what you hear in the bottom end depends on where you sit.

Farfield playback monitors strongly couple to the room acoustic–that's why they aren't used very much except in well-designed downtown studios. It costs a lot to buy the monitors and a lot to fix the room to play them in. The move has been towards nearfield monitors that give strong direct signals and weak room resonance coupling.

The problem here is no bottom end–engineers have to just punt into the mix below 60 Hz. The next move up is to midfield monitors, a compromise, but still no bottom below 45 Hz. Another attempt is to add subwoofers into the system to get the bottom end back up.

ACOUSTIC COLORATION

So far, the distortion of amplitude modulation has been shown to result from room resonance. The mic or listening position has a tough time tracking the low frequency (LF) transients in musical passages. The fast tracking of a room is one important aspect of pro room acoustics. There remains another acoustic gremlin that impacts musical accuracy: coloration. By playing a tone burst into the room at a frequency just off a nearby resonant frequency, both the attack and the sustain of the burst develop a "vibrato" a beat frequency related to the difference between the applied tone and the nearby resonant frequency.

For example, if a 45 Hz note is played into a room with a resonance mode at 42 Hz, there would be a beating effect in the attack and sustain of a vibrato at the difference frequency of 3 Hz. A further coloration problem occurs when the speaker is shut off; the sound decays at the nearby room resonance of 42 Hz, and *not* with the sound of the musical note of 45 Hz. Essentially the note sours in decay. This effect, like the other resonance-controlled playback defects, remain clearly audible by means of an A/B headphone test.

Boom Busters

In Part Two, Mr. Noxon explores what has been done to make bass a welcome guest in the studio.

THERE SEEMS TO BE A POPULAR misconception about the role of bass traps. The uninitiated often say, "I want to kill my resonances with some bass traps". When absorption is added to any resonant circuit, be it electronic or acoustic, only the rate of energy drain from the system is increased. It must be stressed, that from a practical basis, absorption can never eliminate resonance: resonance exists *because* the room exists. Absorption can only reduce the strength and sharpness of the resonance, (its "Q") but not eliminate it.

Sound will build in intensity until there is a balance between the power delivered into the room and the power absorbed or leaked out of it. Increased absorption means the room reaches its peak sound level more quickly. Why? Because the equilibrium sound level attained in the room is lower and not because the energy rise rate is any more abrupt. Adding absorption, however, increases the sound decay rate in the room.

Other benefits are noted at the cold spot. The resonant field strength is weaker overall due to the added bass absorption. The reverb field's reverse phase cancelling effect of the direct wave from the speaker is less strong. As a result, the cold spot "warms" up

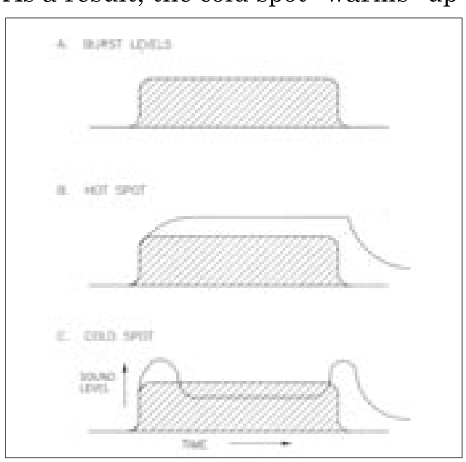


Figure 1. Absorption corrects response.

and the pulses at turn-on and off are accordingly diminished.

As to the coloration effects, added absorption reduces the "Q" of room resonance, the sharpness of its response. Low "Q" rooms lose attack transient and sustain distortion. The beating effects have disappeared and the tone in the decay is the same as that of the driven frequency.

Absorptive damping of room resonances, as we have seen, will improve the dynamic response characteristics of the room. It is quite clear by now that it is the *room* that we listen to in the lower registers. Accordingly, the better behaved the room, the better the track and mix will sound.

A caution needs to be noted at this point. Nearly all recording engineers have access to an RTA, typically 1/3 octave bands. Their experience with electronic equalization, particularly parametric, leads to the desire to see a flat room acoustic response curve. Good luck! It is always a surprise to realize that dynamic transient stability in the room can be developed to satisfaction, and yet the 1/3 octave RTA shows less than 1 dB improvement. Just as it is impossible to fix room acoustics with an equalizer, it is likewise impossible to read room acoustics with an equalizer meter, the 1/3 octave RTA. The narrow band Modulation Transfer Function (MTF) type of test is how room acoustics must be evaluated in the low end.

BASS TRAPS

Many ingenious designs have been developed to provide low-frequency absorption. In the beginning, no doubt a bass trap probably was little more than "great balls of fuzz," fiberglass insulation or batting stacked to the ceiling in the back of the room. Such a system was so ugly that it was covered over with "scrim cloth."

It did, however, provide absorption for frequencies whose wavelength is up to four times the fill depth. A 3 foot deep fuzz trap is effective to the 12 foot wavelength, about 94 Hz.

It is instructive to calculate how deep this trap would need to be to dampen the fundamental room mode now that digital tape can store such low frequencies. Calculate:

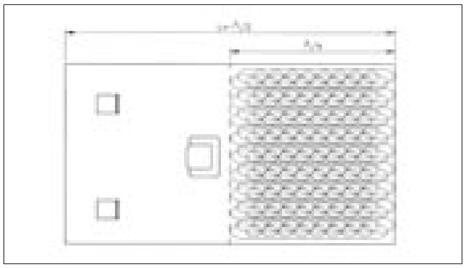


Figure 2. ¼ wavelength trap.

1st Mode Depth = $\frac{1}{4}\lambda = \frac{1}{4}(2L) = \frac{1}{2}L$ = ½ Length

A 24 foot room would need a bass trap about 12 feet deep. Obviously,

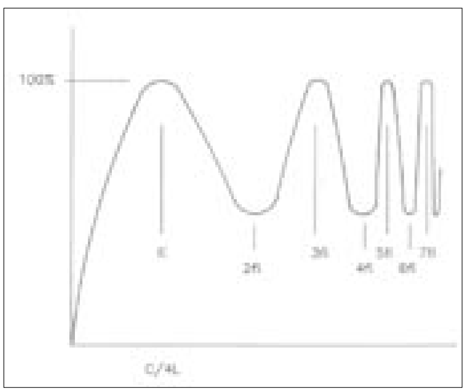


Figure 3. ¼ λ trap response.

converting half the room into a bass trap is *not* an option for most people! An alternative to filling the back

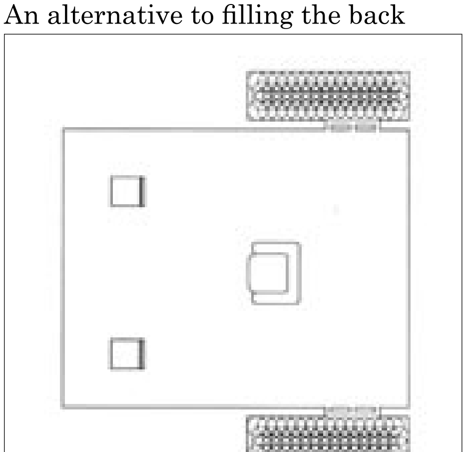


Figure 4. Bass traps located next door.

of the room with fuzz is to remove the closet doors at the back of the room and fill them with fiberglass. The frequency response curve of the ¼ wavelength trap system shows strong absorption on the first, third and fifth harmonics, because the air friction occurs at the position of "sound cancellation" or maximum air motion, typically ¼ λ and ¾ λ from the trap's wall.

SLAT BASS TRAPS

The basic mechanism for sound absorption is the friction of air as it moves across a surface. The more surface and the more air motion, the better the absorption. But large scale bass traps are physically unacceptable in the smaller home recording studio. Another problem with giant absorption is that it makes for an uncomfortable and distracting listening environment, because it is anechoic or too dead sounding.

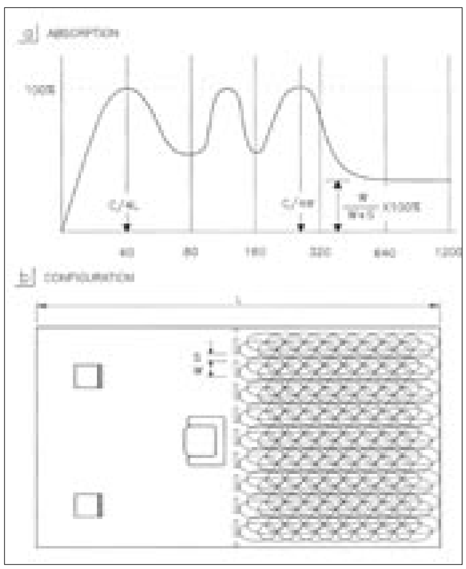


Figure 5. Traps with backscattering.

Consequently, wooden slats are added to most traps, somewhat like a fence. The frequency response for such a system is much more acceptable, since the mids and highs remain lively, yet the bass becomes damped. Larger wavelengths pass easily through the openings between the slats. But when the wavelength is less than four times the slat width, the sound is back scattered.

MEMBRANE TRAPS

The need for low-frequency absorption, combined with the back scattering of mids and highs, has been around for a long time. A different solution was developed early on and became a standard in studio design for forty years. "Membrane traps" utilize thin sheets of plywood, ⅛ inch typically, that are bent into a sequence of curved surfaces around the perimeter of the room. The airspace between the membrane and wall ranges from inches to feet and is packed with building insulation batt.

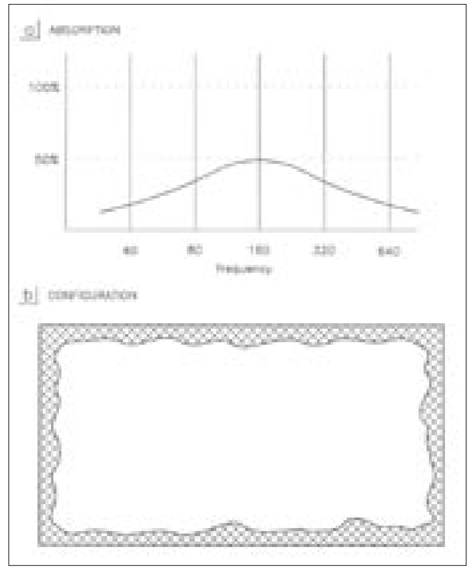


Figure 6. membrane traps.

This technique provides low frequency absorption with the important benefit of continuously curved surfaces creating lots of mid and high frequency diffusion. Rooms with membrane traps are lively, diffuse and well-damped. The efficiency of this technique is only fifty percent at best. This means that twice as much surface area is needed, but we end up with twice as much sound-scattering power. All in all, it's a reasonable tradeoff. These rooms are expensive, but not too different than building a giant acoustic guitar. Their concave curve sections produce local sound focus effects, a problem for mic setups especially in a smaller studio.

PERIMETER TRAPS

Another style of big room acoustics that has been used in control rooms is to lay up row after row of lightweight building insulation along the walls, but angled out from the walls. The hanging batt curtains occupy the outer two-foot to three-foot perimeter of the room. This technique is acoustically comfortable and stable. As the entire room surface has been converted into a great ball of fuzz, there will always be erosion of even the deepest bass energy. The depth of these fuzzy walls can vary depending on the location of the kinetic energy zones for certain problematic modes. The actual volume of room is about twice that of the apparent room. It is somewhat like a welter-weight anechoic chamber. This room can be successful in a downtown designer/contractor studio, but is not an option in the limited floor space of the home or project studio.

PRESSURE ZONE TRAPS

Yet another version of deep bass absorption utilizes the sound pressure-zone concept. The fiberglass batt used in a ¼ wavelength trap is compressed by ten to twenty times into a medium density fiberglass board (commonly referred to as 703). This board is then 'furred out'

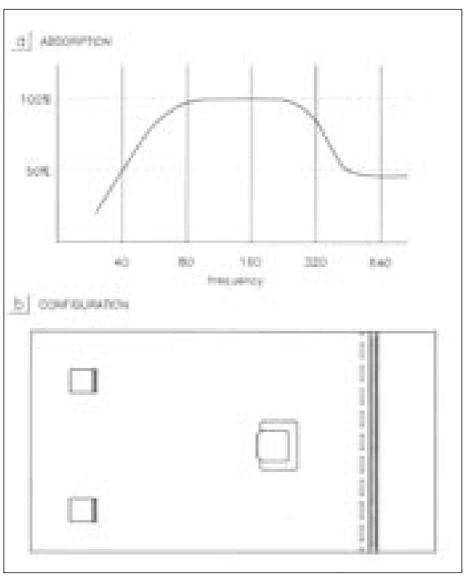


Figure 7. Pressure zone trap.

a number of inches from the wall to produce a very effective sound trap. The major difficulty with this technique is keeping the fiberglass from vibrating as air moves in and out. When the fiat sheet of fiberglass moves, it shorts out the bass trap. Its response curve is spotty, and some frequencies are absorbed while others are not.

The trap design can also be outfitted with spaced slats to back scatter the mids and highs, and if properly made can develop high acoustic efficiency while staying close to the wall. The most common mistake in slat/pressure zone traps is that the slats are set flush against the fiberglass. This chokes off the bass breathing ability of the trap. There needs to be at least a ½ inch air gap between slats and the face of the fiberglass.

The pressure zone trap is a different type of sound trap than those mentioned. It uses lumped parameter acoustics while typical fuzz type absorption uses distributed parameter acoustics. Lumped parameter devices are designed like an electronic circuit with discrete items such as resistors, capacitors and inductors, and can be quite small;

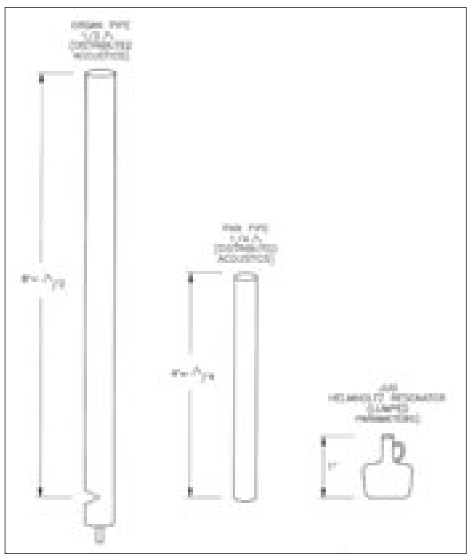


Figure 8. Lumped and distributed parameters.

The distributed acoustic devices use the wave-guide approach to design and are sized directly to the wavelength of the note. For example: the pan pipe (¼ wavelength) and a soda bottle (lumped parameter) can both sound out the same note and equally loud, but the pan pipe will be many times longer than the soda bottle.

IMPROVED QUARTER -WAVELENGTH TRAPS

Rather than a loosely packed fiberglass batt, which always settles, we can glue it to sheets of sound board which can be suspended by wires

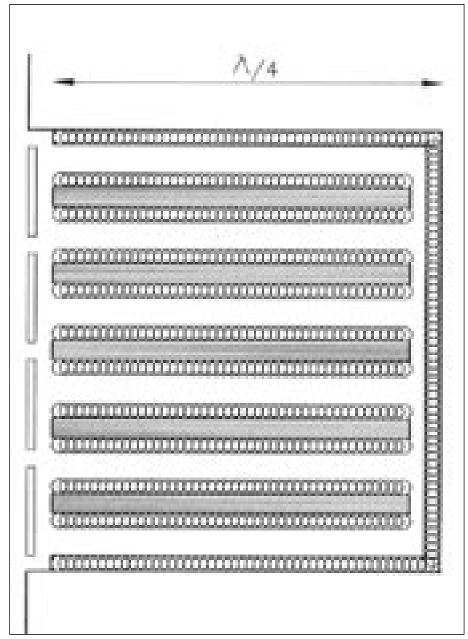


Figure 9. A classic ¼ λ trap.

inside the closet. Nothing much new here; the same response curve as for the "ball-of fuzz" ¼ wavelength trap. The fiberglass does not settle out and so the trap keeps working for years.

SYMPATHETIC RESONANCE TRAPS

The sympathetic resonance or panel trap is a creative cousin to the sound board and fiberglass trap. Often suspended in, supposedly, random overhead positions, these panels are

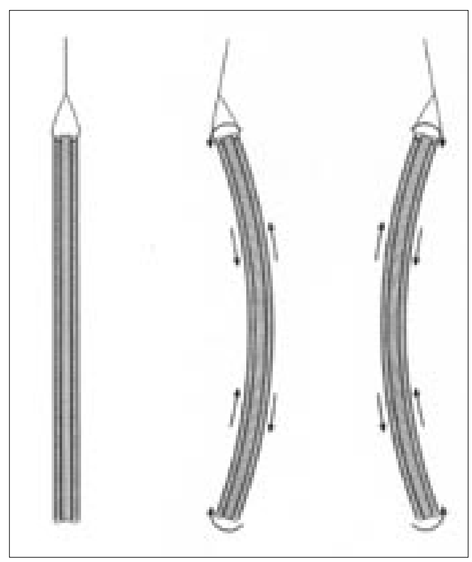


Figure 10. Sympathetic resonance traps.

each tuned by trimming to size and adding weights. Particular frequencies set these panels into sympathetic vibration motion, and the incident acoustic energy is converted to vibrating panel energy.

Dissipation of the energy occurs with the air moving back and forth across the face of the panel as it "twangs." Its own internal friction also dampens its motion. These panels have to be ¼ λ in size, otherwise they would not be able to interact with the sound wave. An 8-by-8-foot panel would function at 40 Hz, if it was correctly tuned. Panel traps work best if aligned to meet the sound wave face on (like a ribbon mic) to engage action. The flat of the panel needs to face the wave front. Too often it is physically impossible to set up a real room with these panels because of size constraints.

HELMHOLTZ TRAP

A classic never-to-be-forgotten sound trap is the Helmholtz trap, which carries the name of a great, old-time German acoustical scientist. Concep-

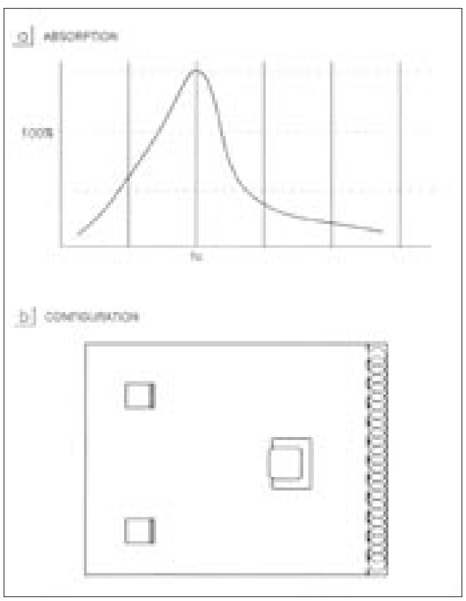


Figure 11. The Helmholtz trap.

tually, the Helmholtz is little more than a jug, tuned with loose batt stuffed inside. However, it usually looks like a panel of ¼ in. pegboard behind which is a 1-3 in. air space fluffed with light building insulation.

The absorption curve illustrates the strong frequency selective property of this type of absorber. Two difficulties exist with using such a trap:

1. It is a single-frequency type, and must be tuned to a known room mode, and

2. The trap's performance is strongly dependent on the amount of batting placed in the cavity and the rigidity of its wall, especially the perf panel. It is difficult to tune.

FUNCTIONAL TRAPS

In the early 1950s, Dr. Harry Olsen, director of RCA Labs and a prolific masterful contributor to audio practice and theory, presented his "functional sound absorber." It was especially unique because of its unprecedented one hundred and sixty percent efficient handling of low frequency sound. He envisioned its use overhead in large rooms and halls. But elsewhere in his literature

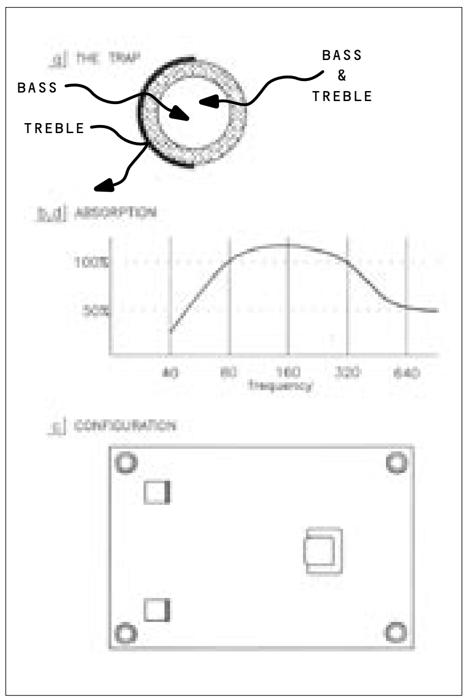


Figure 12. The "functional" trap.

he advises that low-frequency sound absorbers are best located in the corners of smaller rooms.

The "functional sound absorber" is a close cousin to the flat pressure zone trap. The density of the fiberglass for this type system is impedance matched to the radiation impedance of free sound waves in air. Essentially, if the fiberglass is too dense, sound bounces off; if it is too loose, sound goes right through.

The resistance of the surface combines with the volume of the airspace inside to provide a very low frequency response curve for the trap, similar to an electronic RC circuit. By adjusting the value of R and C, the desired RC time constant can be picked for the trap's roll-off characteristic.

Sound absorption is always a function of two factors: the surface of acoustic material exposed to the sound field and the efficiency frequency response of the surface. Dr. Olsen's cylinder bass trap has just

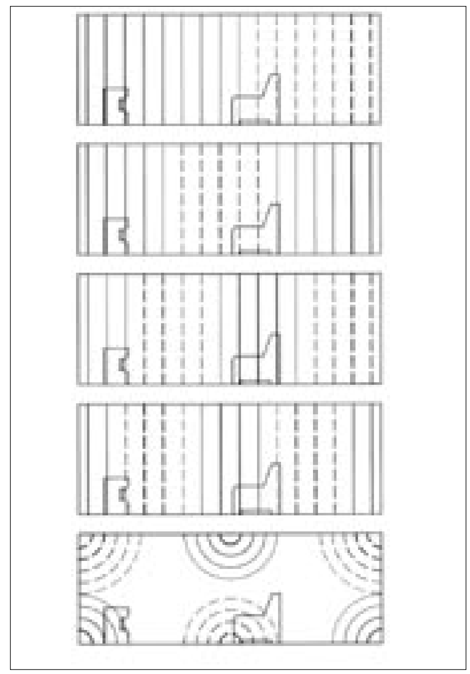


Figure 13. Room resonance modes.

over three times the apparent frontal surface area. Secondly, it is very efficient into the lower frequencies because it is an acoustic circuit of RC time constant design, rather than the more traditional ¼ wavelength "fuzz ball" approach to acoustics.

As with all traps, midrange and high frequency partial reflectivity remains of value. Accordingly, today's pro style functional-type bass trap is usually outfitted with a membrane section to back scatter mid-range frequencies (usually above 400 Hz). These traps are extremely efficient, and particularly when located in the corners of a room. To increase absorption in a selected frequency band or to extend the low frequency response curve, the interior volume can be fitted with a low Q Helmholtz resonator. It is particularly suited as a corner-loaded bass trap in small audio rooms because it is small, efficient, modular and easy to set up, more like studio equipment than a remodel construction project.

RECTANGULAR ROOM DISEASE–HEAD END RINGING

Home/project studios in rectangular rooms suffer from a malady that most designer studios do not have–head-end ringing. Speakers are usually located near the front of the room. From this location they easily stimulate room resonances along the length of the room. It takes about ten exchanges of sound between the front and back of the room to build up the condition of resonance, typically ¼ second.

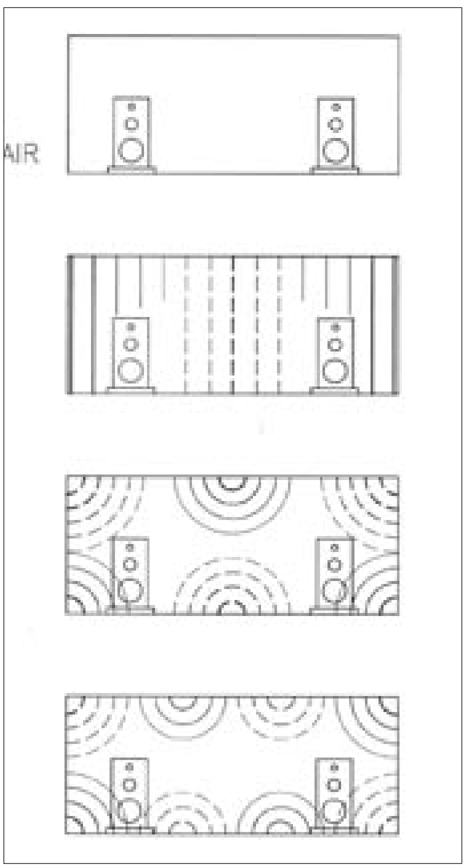


Figure 14. Head end ringing.

Speakers may be far from the back wall, but they are very close to the side walls and floor/ceiling walls in the front of the room. Because of these short lateral dimensions, side to side and vertical resonances can build very quickly (within 1/20 second in the front end of the room), long before the entire room Can be engulfed in the resonance. This fleeting, quick resonance is called "head-end ringing" and because of the time scale, dramatically affects imaging and the color of attack transients.

Head end ringing is not a deep bass problem–it is a mid bass coloration effect due to a lack of bass traps in the front end of the room. Designer studios with the Reflection Free Zone (RFZ) cup shaped front end don't have this problem. The raked walls and ceiling eliminate any opportunity for reflections to stay and build up in the front of the room. But with home and project studios set up in rectangular rooms, head end ringing is a major problem that near-field or mid-field monitors cannot even avoid. Typically, playback monitors are located about halfway between floor and ceiling, and about one-third in from the side walls. The classic head end ringing problem occurs at about 140 Hz. A substantial distribution of mid-bass traps on the walls and in corners of the front end of the audio room is the only way to control head end ringing.

EPILOGUE

Over the years bass trapping has matured unique to the recording industry. We don't usually see them in press release photos because they have always been built in behind the walls of the designer/contractor studio. Nevertheless, bass traps are a tradition that is integral to the definition of a recording studio or control room. They are the primary acoustic consideration that separates recording rooms from regular rooms. Although many versions have evolved, one thing is for sure: bass traps have been, are now, and will most probably continue to be the cornerstones for the pro room acoustic.

But these are modern times and the availability of personally affordable studio grade equipment is changing the face of the recording industry. Home and project studios are being set up at a ratio of ten to one compared to the traditional designer/contractor-built studio. This new and rapidly developing division of the recording industry may be wired like downtown studios, but their room acoustic is all too often set up with no more than a couple of pieces of foam tiles and particularly depleted of bass traps. Consistency is always important, and the first rule in studio design is that it must "look like a studio." In this sense the topic of bass traps in the designer/contractor-built studio and the home/project studios do have one thing in common–no bass traps are visible.

There is only one reason that studios have to look like studios– to help establish client confidence. But this requirement for designer/contractor studios does not apply in the home/project studio.

To a large degree, the owner of the home/project studio *is* the client of the studio, The home/project studio may not have to look like a designer/contractor studio in order to do its business, but it certainly has to act like one. Since bass traps won't be built in behind the walls of any home/project studio, they will have to be set up in front of the walls and corners of the room. For the first time, engineers will simply have to look at bass traps.

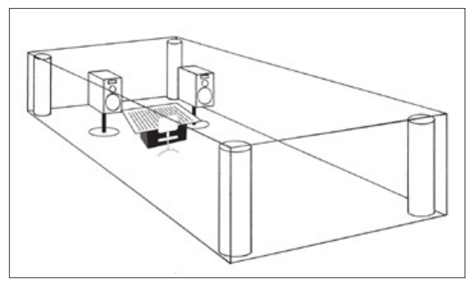


Figure 15. Bass traps for a listening room.

Essentially, bass traps are "coming out of the closet" in order to get back to work in the home/project studio. After all, any chain, even the home/project studio audio chain, is no stronger than its weakest link, and bass traps are critical to the last link of the audio chain—the room acoustic.