SYNERGETIC AUDIO CONCEPTS

SYN AUD CON

newsletter

Volume 20, Number 2
Winter 1993

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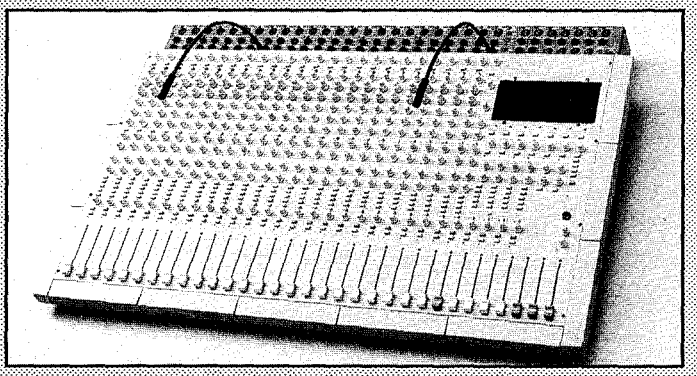

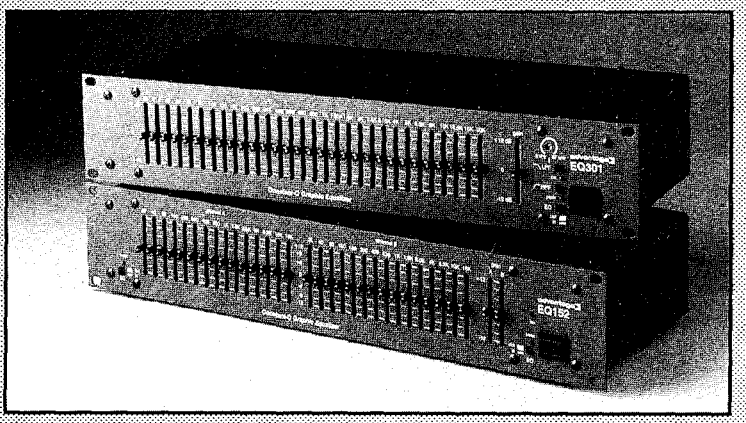

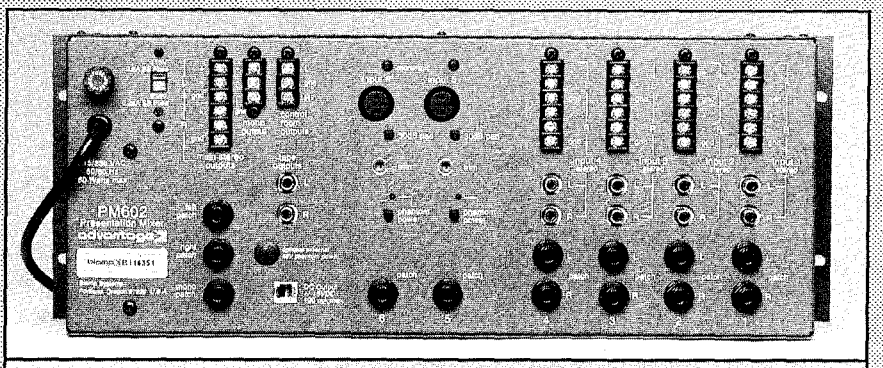

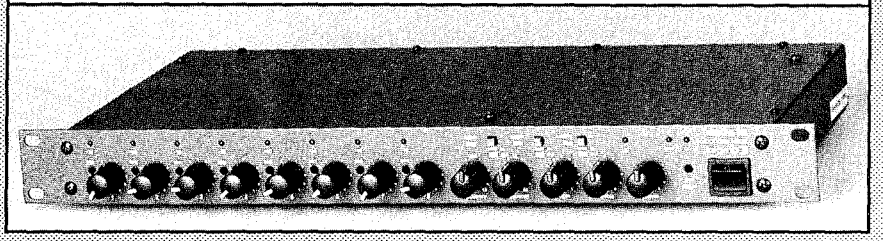

SYNERGETIC
SYN AUD CON
AUDIO CONCEPTS

EXCHANGE OF IDEAS

I met a man with a dollar
We exchanged dollars
I still had a dollar

I met a man with an idea
We exchanged ideas
Now we each had two ideas

Synergetic: Working together; co-operating, co-operative.

Synergism: Co-operative action of discrete agencies such that the total effect is greater than the sum of the two effects taken independently.

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Carolyn Davis

Design & Layout: Dashia Meadows

The information conveyed in this NEWSLETTER has been carefully reviewed and believed to be accurate and reliable; however, no responsibility is assumed for inaccuracies in calculations or statements.

Syn-Aud-Con Newsletter (ISSN—07397518) is published quarterly for $35 per year (U.S. and Canada) and $40 per year outside the U.S. by Synergetic Audio Concepts, 12370 W. Co. Rd. 100 N, Norman, Indiana 47264. Second-class postage paid at Norman, Indiana 47264.

If you attend a Syn-Aud-Con Seminar during the year, your subscription will be extended one year. (Your registration fee includes a $35 subscription for one year to our Newsletter and Tech Topics).

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When Do I Renew?

You can check to see when your subscription will expire by checking the mailing label on the envelope in which your newsletter was mailed. In the upper righthand corner, beside the name, a date will appear (i.e. 1-93). This means that you will receive this issue and it will be the last issue sent unless you renew. Renewal notices will be sent at this time. You must renew before the next quarter's newsletter is mailed or your subscription will become inactive.

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— Biamp—

An "All-American" Success Story

Biamp Systems sought out Syn-Aud-Con early in its history with the result that their president, Syn-Aud-Con grad Ralph Lockhart, has been uniquely sensitive to serving the sound contractor market.

Ralph Lockhart has led Biamp into a financial partnership with Rauland-Borg Corporation with synergistic results for both companies. This partnership has allowed Biamp to reach an expanded market with its consequent "feedback" from key contractors around the world.

Biamp is located in the both beautiful and bountiful high tech Sunset Corridor of Portland, Oregon. Often called the Silicon Forest, this area has a collection of major research oriented electronic companies and their employee pools. This has equipped Biamp with talented and motivated personnel who serve, in the broadest sense, their customers with superior products, rapid shipment, quick turnaround maintenance service, and practical application support.

Featured on the front of this newsletter are some of Biamp's typical 'Advantage' products designed and sold with the professional sound contractor in mind.

All Biamp and Advantage equipment are designed, engineered, and manufactured in the United States.

Biamp has been a Syn-Aud-Con sponsor for the past six years and we look forward to many more years of friendship and technical achievement.

TOA Research & Development

John Royer specified the TOA SAORI digital processor in the Indiana State Fair Pepsi Coliseum in order to efficiently handle the complexity of the myriad venues it supports. John is very pleased with the SAORI and the support TOA has provided.

As a result, John Murray with Tad Inui (who was escorting the designer of the SAORI, George Kuryama, and Kiyohiro Kurisu, a new research engineer at TOA Research & Development) met with us in Indianapolis to see and hear the installation, figure 1.

639 Altec Microphone

John Royer chose that moment to present me with a 639 Altec microphone he had discovered in his inventory, figure 2. Only gray heads can remember life prior to the 639 (originally the Western Electric 639). The uniqueness of this microphone was its ability to maintain a cardioid pattern over a wide bandwidth. It accomplished this in a very clever manner. The basic idea was to place both a dynamic microphone diaphragm and a ribbon microphone's ribbon in the same area of a sound field by placing them in close proximity to each other and then electrically combining their outputs, figure 3.

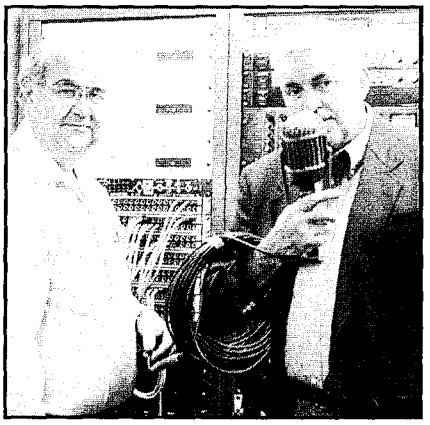


Figure 2. John Royer (L) gave Don a working Altec 639 Altec microphone.

In the 639, the dynamic microphone was omnidirectional at the lower frequencies and then gradually become more directional at the higher frequencies. The electrical output of the ribbon microphon could, by careful equalization, be filtered out around 3000 Hz, thus allowing the increasing directivity of the dynamic microphone to assert itself. The result was a wider bandwidth cardioid pattern than had previously been attainable. Through switching of the simple components various patterns could be generated, figure 4.

This microphone was in use during a time period when there was the possibility of it having had Franklin Roosevelt, Harry Truman, etc. use it when they visited the Indianapolis area. John Royer not only picked a working model but went to the trouble of making an adaptor from its connector to present day connectors.

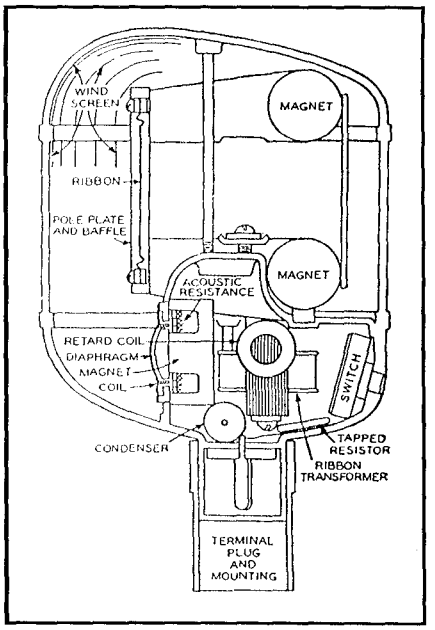


Figure 3. Cross-section of Western Electric 639 cardioid microphone. (From "A New Microphone Providing Uniform Directivity over an Extended Frequency Range" by Marshall and Harry, Journal of the Acoustical Society of America, April, 1941.)

Figure 1. Pat Brown of Pro Audio Services, installing contractor, showing SAORI designer, George Kuriyama, the SAORI in operation.

Figure 4. John Murray, Don Davis, Tad Inui, George Kuriyama and Kiyohiro Kurisu with the 639.

R & R on a Busy Trip

As part of our "Hoosierization" program, our TOA friends came down to the farm where we introduced them to the .45 caliber way of life. Poncho made immediate friends. Tad Inui having vacationed at the farm with his family in 1987 quickly got back in the swing of things with the Honda, the goats and the dogs.

These are very bright, energetic, young men who are paying attention to the needs of our industry and outputting really useful products.

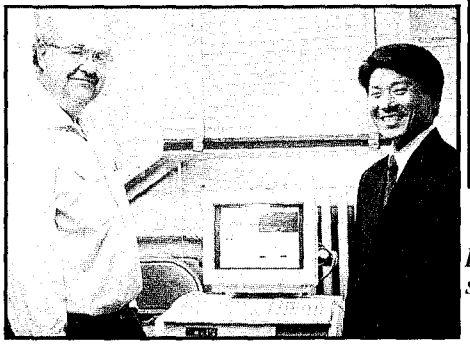
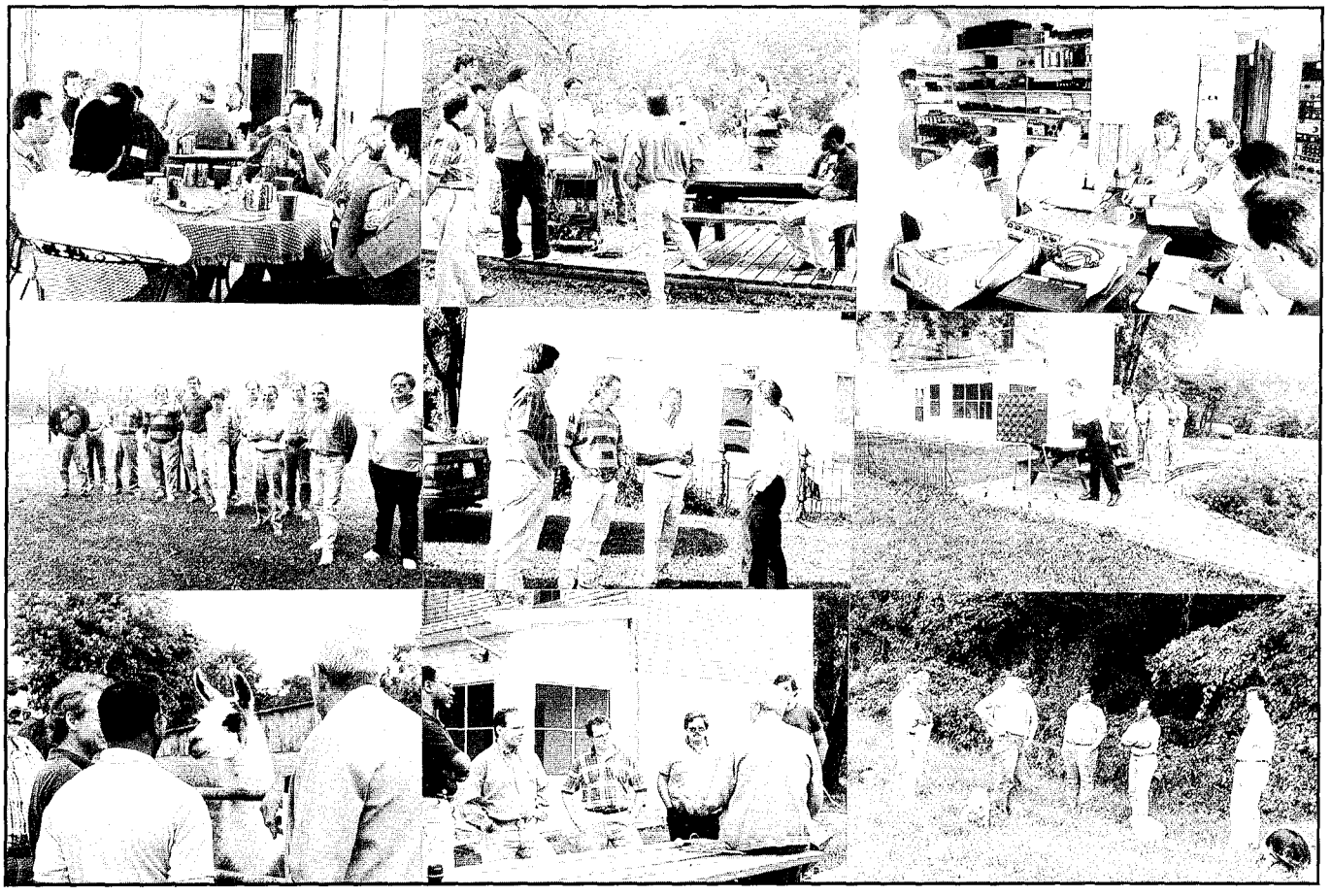


Figure 5. The inscrutable John Royer with George Kuriyama demonstrating the SAORI's PC control software via computer interface

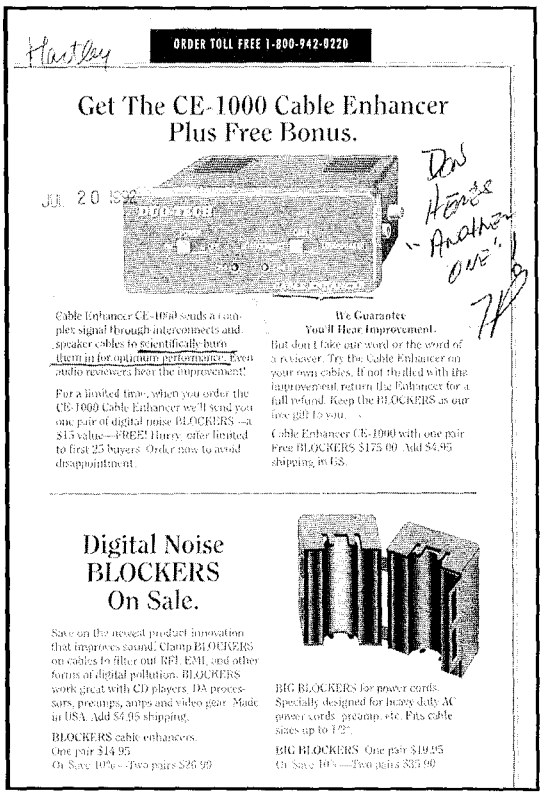
September Farm Seminar

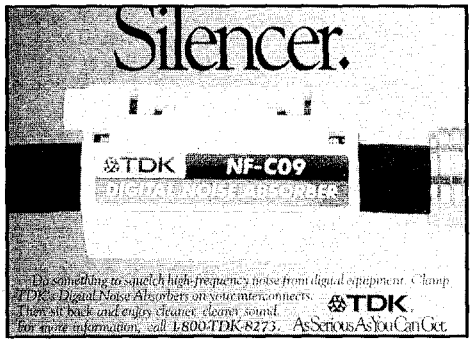


It's No Longer Funny

Hartley Peavey likes to send us anti-gravity audio ads to allow us a mutual hearty laugh. These ads are funny to someone that knows better. What's not funny anymore is the realization of how many people don't know better. Actually what all this represents is the residual of Medieval thinking evidenced in modern times. Even TDK is doing it.

Hartley also included an ad for "The world's finest speaker cable" at $100/ft and close to $1,200 for 12' pair.





The futility of attempting to logically answer mystical nonsense reminds me of Galileo's telescopic observations of the planet Jupiter and its four moons, or satellites, circling the planet. This provided a model of a miniature solar system and proved that all celestial bodies did not revolve around the earth as was then believed (1610). The Italian Astronomer Francisco Sizi attempted to refute the observed data of Galileo with the following:

"There had to be exactly seven planets (including the moon and the sun) corresponding to the seven days of the week, to the seven metals of alchemy, to the seven openings to the head, and to the seven cardinal virtues. He further argued that the satellites of Jupiter were invisible to the naked eyes, and thus could have no influence on humans and; therefore, had no real existence."

The modern media also deals in seeming relationships and has helped publicize many "Buzz Words" which in turn allow the mindless media mental memory to say when they read key words like RFI, EMI, digital pollution to say, "Of course, I've heard of that."

Idle idol worship is as ancient as man and manifests itself in "if I buy an XYZ car, I'll be an expert driver, if I buy an ABC rifle, I'll be an expert shot, and if I dress and act like Clint Eastwood, I'll be fearless and tough." It's an easy extension to "if I buy enough audio gadgets, I'll be an expert listener." If you take a thoughtful look around you at today's society, you'll realize that all this is not as funny as it might first appear, but then again the gravity of the situation may not affect you until you're my age.

Understanding Harmonics in Power Distribution Systems

Posey Bowers from New Orleans sent the following:

"I have just finished watching Fluke's *Understanding Harmonics in Power Distribution Systems.*" Seventeen minute VHS, $19.95 from John Fluke, 800-526-4731. I can certainly recommend this thorough, professionally produced video to any sound contractor with twenty bucks to spare. The video explains the problem, explains what tests are appropriate and even details corrective measures.

"For those without a spare twenty, I recommend Fluke's Application Note, *In Tune with Power Harmonics,* 16 pages, free in the November issue of Electrical Construction and Maintenance or free from John Fluke. 800/87-FLUKE. The Application Note presents nearly the same information as the video."

"Never Again—We'll Fight to the Death Before We Will Submit Again"

Prof. dr ..... of the University in Zagreb in a recent letter to us has described the tragedy going on in Yugoslavia. (We have withheld his name for obvious reasons and we have edited out some material for his protection.)

Prof..... was the gentleman who so generously entertained us at the University when we were in Zagreb two years ago and who told us that there was a potential for this kind of violence. He's a man near my age with a clear memory of World War II and its atrocities. As he had shared with us his memories of those days, his eyes and face had taken on a sad, yet stern, determined look as he told me, *"Never again—we'll fight to the death before we'll submit again."*

We are not privy to the high consuls of this world, but to our sense of things the refusal by the west to send arms to the Bosnians so they can defend themselves is an obsenity. The reason given by our UN Envoy Cyrus Vance was, "That if we arm the Bosnians, the Serbs might get angry and do more damage." God help the Bosnians, but God help the U.S. if that's the mental state we support.

Zagreb 25.11.1992.

Dear Mr. Davis

.....as you know, we have heavy time here, which capture our minds and activities. Despite the war we try to work, have lectures and all needed activities on our faculty, as Zagreb is not directly in the war zone, although, we had bombardments and heavy fighting in Zagreb and surroundings.

As you are interested in our land, I want to tell you few words about events that happened here. Croatia wants to separate from centralism and communistic Yugoslavia. Serbs who control the army attack Croatia. They torture, slaughter and kill children, women and men, everybody who are not Serb, especially if they are Croats. They want to make a "Great Serbia," exactly by the fascist scenery, and intent to clear Croats from their own land. Serbs behave like wild beasts, they destroy cities (I enclose a picture of Vukovar) and villages, they destroy churches, industry plants, schools and especially Croat cultural goods and buildings.

Croat formed their own army (the whole land stands) and with great victims and efforts defend their land and form free democratic state of Croatia (although about one fourth of land is still under occupation).

Now the war is going on in Bosnia and Hercegovina, there Muslims and Croats fight for their lives. This war is more bloody and heavier than that in Croatia, because people there were not quite prepared, so number of victims are till now about fifty thousands killed. Serbs hold in Bosnia many concentration camps with civilians, they make mass liquidation because they want to have clear land, which they occupy, from all non-Serb people. More than half a million refugees came in Croatia and in many countries of Europa - terrible and not believable but it is unfortunately true at the end of Twentieth Century.

What to say at the end of this letter - we believe in better future, justice and peace, and we will survive.

I thank you for the care you offer us by sending the Newsletter, it's a very interesting and up to date literature.

I want to send many kind regards to Mrs. Carolyn and to you, and I wish you a Happy Christmas and a Happy New Year.

The Null Frequency Interval

by Kurt Graffy, Paoletti Associates—San Francisco, CA

Kurt Graffy is a teacher par excellence. He has been an assistant instructor for the past three years for a fall farm class. He preapred this superb explanation of the Null Frequency Interval.

The NFI (Null Frequency Interval) SSE pp364-366) should perhaps be more accurately described as the CFI, (Comb Filter Interval). A comb filter is the frequency domain representation of two signals which are misaligned in time (or distance and phase) from each other. The CFI may describe either of the two elements of the comb filter, the NFI or the PFI (Peak Frequency Interval), since the spacing of the combs (in frequency) is identical whether one is measuring nulls or peaks of the comb filter display.

One may determine the distance/time offset of the two sound sources by determining the frequency interval between either the nulls or the peaks of the comb filter and using the following relationship:

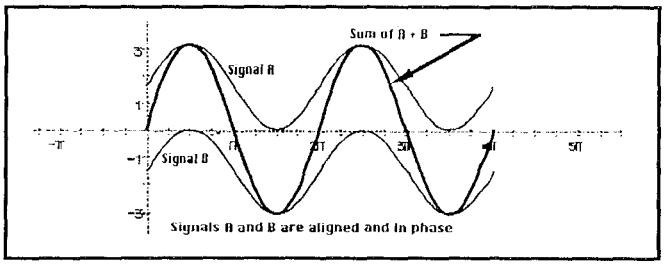
$\lambda = c/f$

where: c is the speed of sound (1130 ft/sec or 343 m/sec)
f is the frequency in Hertz
λ is the wavelength (in feet or meters)

(Since the wavelength is analogous to distance in this case, we could substitute 'd' for distance in place of λ.)

Thus, we can see that for a comb filter with 1500 Hz spacings between either the null frequencies, or between the peak frequencies, the wavelength (or the distance between the two displaced sources) is equal to:

$\lambda = 1130/1500 = 9"$



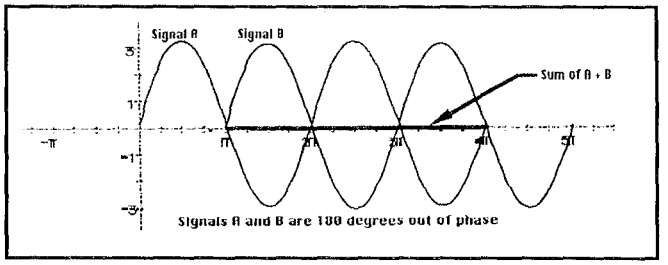
Since the NFI is directly proportional to velocity 'c' and inversely proportional to distance 'd' (or wavelength) then:

NFI = c/d, therefore d = c/NFI

If d = c/NFI, then in our example, where c = 1130 ft/sec and NFI = 1500 Hz

d = 1130 ft/sec/1500 Hz

This equals .7533' or, converting to inches: .7533' x 12" = 9"



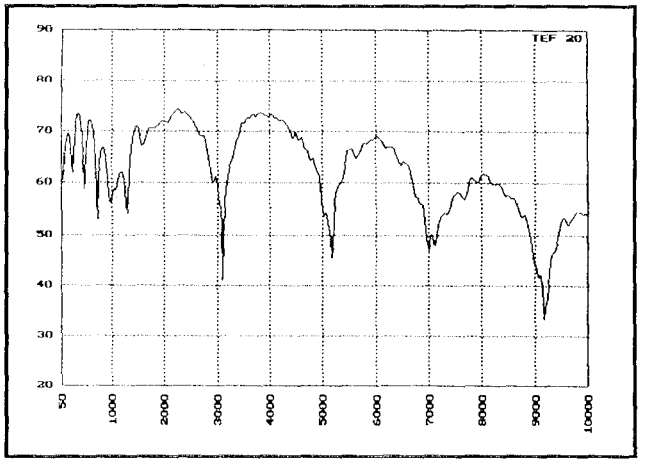
However, in looking at the illustration above, it can be seen that the comb filter nulls will be caused by the two signals being out of alignment by 180 degrees, or half a wavelength. What we have solved by using the NFI equation is the wavelength of the NFI. Two 1500 Hz signals separated by this distance, will however, be in phase with each other and will sum to a peak (see first illustration).

What we want is the misalignment distance which will provide a null, and this will occur at a distance equal to one-half wavelength (second illustration) and odd multiples thereof ($\lambda/2 \therefore 3\lambda/2, 5\lambda/2$, etc.).

Thus, in our example, the first Null Frequency at 1500 Hz represents a misalignment of d/2 (or half wavelength) which in this case since d = 9", becomes 9"/2 which equals 4.5" of misalignment.

An Example of Mis-alignment or Mis-Synchronization

Shortly after Kurt wrote up the correct explanation for the Null Frequency Interval, we made a measurement of two speakers misaligned in a cluster. In this example, the first notch of the comb filter appeared at the crossover, creating a comb filter much wider than would be expected. Fortunately the measurements we made were made prior to synchronizing the speaker cluster and the comb filters were removed.



1993 Rigging Seminars

by

Dr Randy Davidson and Harry Donovan

If I were a young man and was looking for an activity that was technically challenging, required ingenuity and personal skill, and would be work that would always be in demand, then rigging would surely qualify. It's a field of endeavor that pays skilled professionals well for their efforts. Such professionals accept awesome responsibility for the safety of others who have to work under, around, or on their rigging. Mistakes in rigging can be fatal, therefore, the rigger is not privileged to learn by his mistakes like we are in audio. As we say, if bad audio were fatal, audio would be the leading cause of death! WAG calculations are an abomination in rigging work.

When we have need of rigging skills we call upon an internationally acknowledged expert with thousands of jobs to his credit, none of which have ever failed in any way. Harry Donovan and his friend, Dr. Randall Davidson, are offering rigging seminars during the winter of 1993. We feel that it is so important that everyone involved in installing sound systems, whether for fixed or temporary systems, MUST be knowledgeable about rigging sound systems. Our industry cannot afford a catastrophe nor can you.

The Davidson/Donovan seminars are unique in that they are broadly based to include valuable rigging information, not just for the usual theatrical and stage rigging, but for rigging associated with a sound contractor's work, thus information for electroacoustic consultants and loudspeaker manufacturers.

Where does the sound contractor get the training to assume the responsibility for the hanging of a multi-ton array in an auditorium or arena?

We became aware of, and impressed with, Harry Donovan when we attended the 1991 JBL Conference. His presentation was impressive and memorable. Shortly after that we became involved with the design of a new sound system for the Pepsi Coliseum at the Indianapolis Fairgrounds which would replace a 25 year old sound system.

We began to call around to find out who accepts responsibility for the rigging of the sound system. We had often heard sound contractors complain about the lack of direction from the electroacoustic consultant. As Steve Simpson commented one time, "Apparently they want us to use chewing gum to hang this multi-ton array." I found that consultants will not even mention the word, rigging. "That is the responsibility of the sound contractor."

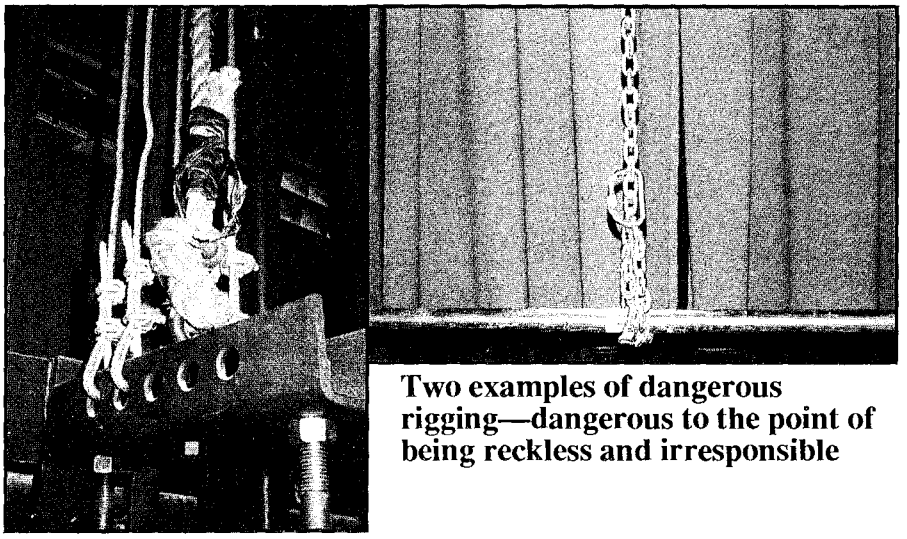
Where does the sound contractor get the training to assume the awesome responsibility for the hanging of a multi-ton array in auditorium or arena?

Oh, yes, the sound contractor is always advised to hire a structural engineer - and this is a must! But, how many sound contractors do it? And just how responsible is the structural engineer's stamp, except for insurance purposes?

We had recommended an installing sound contractor for whom we had a very high regard. Management at the Coliseum felt the rigging was in good condition "because it had worked well for 25 years." When we realized we were leaving the sound contractor, Pat Brown at ProSound Audio, responsible for the safety of a 25 year old rigging system, he and I agreed we should call in Harry Donovan.

Donovan spent the afternoon with Technical Director, John Royer. Unfortunately, we were out of town and couldn't be present. But that afternoon took $10,000 out of Royer's budget immediately with more to come later.

We talked to Harry Donovan about the importance of rigging information getting to the sound contractors and loudspeaker manufacturers. That is when Donovan began to give serious consideration to planning rigging seminars with Dr. Davidson.



Two examples of dangerous rigging—dangerous to the point of being reckless and irresponsible

Distortion Measurements

"Hopefully this abbreviated discussion has stimulated your thought regarding the use of the word 'distortion' and the appropriateness of thinking in terms of undesired signals instead."

We discuss in class how specifications are often given in the least useful parameter such as power in watts instead of dBm. When the amplifier output power is in dBm that number can be directly added to the EIA sensitivity of a driver with the answer then in dB-SPL (L_P at 30' for the amplifier power).

Nonlinear behavior in electronics and acoustics is distorted by the same inappropriate choice of parameter, namely percentage.

Applying Linear Measurements to Nonlinear Devices.

Dick Heyser used to point out that the industry was applying linear measurements to nonlinear behavior of devices. We have watched audio men and women make measurements using a "distortion analyzer" that gave them the "percentage distortion" without a flicker of recognition that they didn't know how much of the value they obtained was caused by noise, hum, or nonlinear components.

How to Measure Nonlinear Behavior

The preferred way to measure nonlinear behavior, so far as we are concerned, is to use a spectrum analyzer that has sufficient frequency resolution to allow the second harmonic to be identified. This provides you with a very useful parameter, namely how many decibels below the desired signal is the undesired signal. This viewpoint relates directly to how likely the undesired signal is audible or not. Since such measurements are based on voltages, the conversion to percent is done by:

$$10^{\left(\frac{-dB}{20}\right)} \times 100 = \%\ \text{nonlinearity}$$

-20 dB is 10%
-30 dB is 3.16%
-40 dB is 1%
-50 dB is 0.316%
-60 dB is 0.1%
-70 dB is 0.0316%
-80 dB is 0.01%

What Distortion is Acceptable and What Isn't?

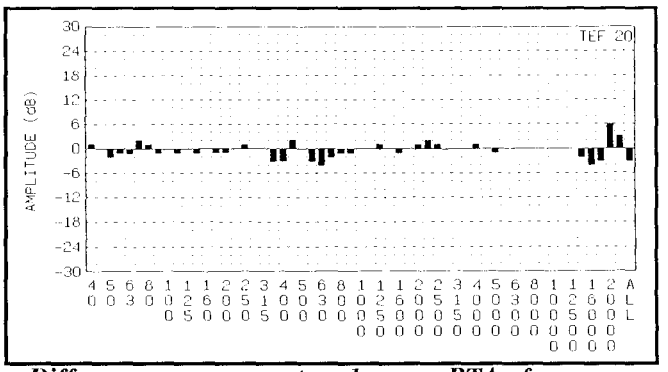
The audibility of undesired signals depends on many factors. Because harmonic nonlinearities occur in nature, music, voice, etc., we are relatively tolerant of them and -40 dB or 1% seems to be a realistic point below which the undesired signals of this type are no longer audible. Pre-echo on a tape or disc, on the other hand, is highly audible even when 60 dB below the desired signal because of its unnaturalness (echos just don't come first in real life). A given noise can be very audible in a quiet studio and totally masked in a large arena by a more predominant noise.

The Time Behavior of Undesired Signals

The time behavior of undesired signals can, on occasion, be the deciding factor in audibility. Nonlinear behavior has to follow after the desired signal in relative time. Your main test signal is your desired signal. In passing through the system it "triggers" nonlinear behavior which then takes on a growth and decay of its own after the desired signal has passed. Now minimum phase behavior is undesired and invariably has a time domain signature of its own.

Hopefully this abreviated discussion has stimulated your thought regarding the use of the word "distortion" and the appropriatness of thinking in terms of undesired signals instead. Many Syn-Aud-Con classes are surprised at my lack of interest in conventioanl distortion measurements. I hope this discussion clarifies where my interests do concentrate.

The New Year and Resolution



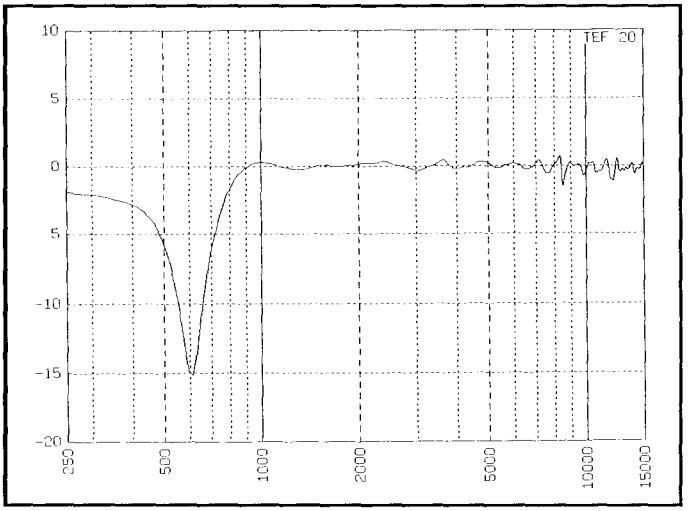
Difference measurement made on an RTA of two devices out-of- alignment.

We are not talking about New Year resolutions but a new year in which to talk about resolution. While we still occasionally encounter individuals who believe they are seeing 1.0 Hz resolution on their dual channel FFTs, a majority of Syn-Aud-Con grads have a more realistic view of frequency and time domain resolutions. Given adequate instrumentation, the time domain resolution is determined by the frequency bandpass of the device under test.

In the frequency domain, given adequate instrumentation, the frequency resolution is determined by the time window employed and in acoustic frequency measurements, by the time window sans reflected energy.

To illustrate this point, Don Van Oort's measurements of a notch that appeared as a result of a crossover polarity reversal were made 1/6 octave on a TEF-20 which has ANSI filters that are steep. At 600 Hz the bandwidth for 1/6 octave is 69 Hz (i.e.: 11.5% of the center frequency).

A majority of instrumentation users in sound contracting work use 1/3-octave real time analyzers. At 600 Hz the filter bandwidth is 138 Hz (23% of the center frequency). If the filter "skirts" aren't sharp - say only 6 or 12 dB per octave - then a narrow (defined as 200 Hz or less) dip in the frequency response will not be visible at 600 Hz.



Difference measurement made on a TEF 20 of two devices out-of- alignment

It should be noted that the notch is not a test of polarity (i.e., the notch may be the in-polarity connection but the two drivers are out of alignment.) Phase measurements are the way to verify polarity.

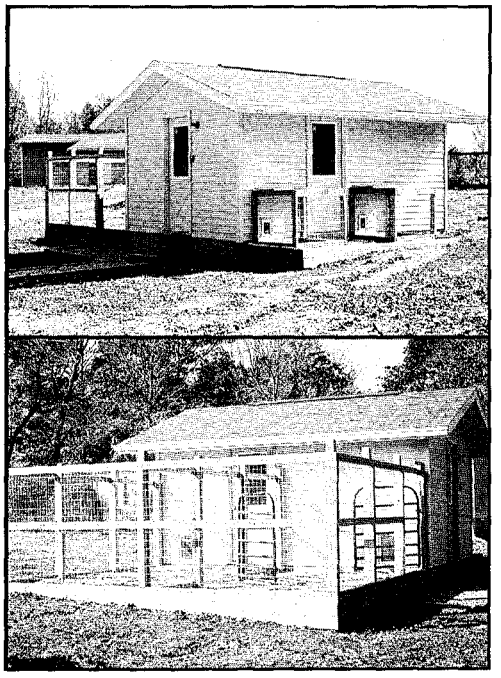
"You Don't Need No Permit For a Doghouse"

The new addition to the buildings at the farm, number ten, is a house for the dogs and cats since eight animals around the stove is a problem similar to Bosnia.

The building is divided into a doghouse and a cat house. They have their own entrance-exits to their outside pens. The building has electric heat, running water and a small kitchen for dog and cat meals.

Carolyn called into the county courthouse to apply for a building permit and was told, "You don't need no permit for a doghouse—lady."

We took this official at his word and hence we have a permitless home for wayward orphan animals.



Syn-Aud-Con 1993 Seminar Schedule

Looking forward to 1993 in audio and acoustics, we are planning a full schedule of farm classes. 1993 is our twenty-first year as Syn-Aud-Con. Back in 1973 we predicted the digital revolution—1993 sees it hard upon us. Complete digital consoles (TOA), digital crossovers (JBL, Peavey, Yamaha, TOA) and of course, marvelous combinations of digital personal computers; superb instrumentation such as the TEF-20 and the Ariel SYSid dual channel FFT are present day affordable facts.

We have witnessed 25,000 watt full frequency range stereophonic systems in a large 6600 seat church (First Baptist Church in Orlando, FL). Computer design of sound systems now includes binaural auralization with approximations of "In-the-Ear" transfer functions. True digital equalization (IED & White) has arrived and as have interactive measure-adjust approaches that include direct indication of non-minimum phase portions of the spectrum.

Our 1993 farm classes introduced all of these concepts in their most applicable form. The basics remain remarkably the same, but the "black boxes" are radically different.

Syn-Aud-Con grads continue to have a distinct advantage over non grads in that they are able to properly evaluate new technologies promises in the bright light of audio and acoustic fundamentals.

Perhaps the most amazing fact in 1993 is that Syn-Aud-Con is still without a competitor after two full decades. A third decade will undoubtably see even greater changes than the past two. We optimistically look forward to talking one day about the opportunities of 2003. If we do, you can be sure they'll have sprung from fundamentals made ever clearer with the passage of time.

New Class Date in May

The date in May is different than previously published—for two reasons: Many tell us that holding the seminar Thursday-Saturday makes it impossible for them to attend—touring sound engineers, religious affiliations, etc. Therefore, the May class is scheduled for their needs. Ordinarily we arrange to end on Saturday so that those flying can save substantially on air fare by staying over Saturday night.

Secondly, the date is changed so that out-of-towners can attend the Indy 500 Time Trials, if they wish. If we know in advance, we **may** be able to arrange with John Royer to go up in the tower to see his sound operation. (John's official title is Assistant Technical Director of the Indy Motor Speedway Radio Network, but he wears many hats.)

One of the great experiences for Gene and Charlotte Patronis and for Carolyn and I was in late March '92. We were in Indianapolis to test the new AcoustaEQ software on an existing old sound system in a large arena. After our very successful tests on a 25 year old Altec multicell system, Dr. Patronis asked John Royer if he could see the Indy 500 track. John graciously agreed and we went to lunch at a restaurant on the edge of the track grounds (500 acres). As we were eating, we heard the hair raising roar of an Indy car in the distance. We ran to the window and we could see the flash of a car on one part of the track. We hurriedly finished our lunch and went over to the track to see Roberto Guerrero unofficially break the track record at 230.279 mph. The track had been rented for testing. We watched from the pit wall and from the tower. Gene and Charlotte's first visit to the track is one they won't soon forget.

❖ 3—Day Seminars—$550

Farm—Norman, IN

Sound Engineering Seminars

May 18-20	***August 19-21***
June 17-19	***September 16-18***
July 15-17	***October 14-16***

An Assistant Instructor (to be announced) will be present at each of the seminars at the farm. Also class size is limited to 12 so that those attending can have hands-on and work closely with their instructors.

Serving Cable

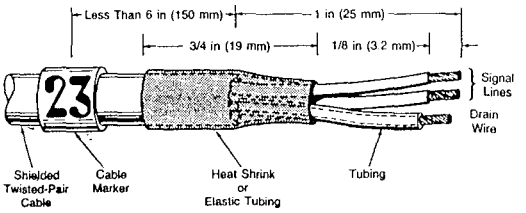


Fig. 15-1. Shielded twisted pair of wires

Recently I received a call from Ski Bienkowski of Fresno, CA asking if I knew of an "in print" definition of serving cables. It seems Ski had a rebellious contractor that didn't want to do what Ski had specified (i.e. all cables were to be dressed and served). We found the required definition and full description in a book written by Syn-Aud-Con grad, Philip Giddings. The book is entitled *Audio System Design and Installation* published by Sams. Reproduced here is the data sent to Ski. Now you have an easily available "printed" form for your specification backup.

Steps for Preparation of Shielded Twisted-Pair Cable

1. The cable is cut to the desired length and identified with a wire marker, preferably a slide-on type
2. 1–1.5 in (25–37 mm) of outer jacket is removed without nicking the inner conductors
3. Most cable types will have one of the following shields:
   (*a*) *Foil shield*—The exposed foil shield is also removed without nicking the conductors. This leaves the drain wire exposed. Note that cable with the foil bonded to the outer jacket (such as Belden 9451) is available so that both are removed in one operation
   (*b*) *Braid shield*—A dull pointed tool is used to spread the braid apart at the base of the stripped wire. The conductors are then pulled or pushed back through the hole, leaving the empty braided shield as a drain wire. Alternatively, the exposed braid is unraveled, without breaking any strands, and twisted together into one large drain wire
   (*c*) *Spiral/serve shield*—The exposed wires are unspiraled and twisted into a drain wire. Note that in all cases, if the shield is not being connected, the drain wire is not required and is cut off close to the jacket. Step 4 can then be omitted
4. A 3/4-in (18-mm) long piece of tubing (spaghetti) is slipped over the drain wire. The inside diameter of the tubing should be only slightly larger than the drain wire—3/64 in (1.2 mm) is good for 22 AWG wire. Teflon and neoprene tubing which withstand soldering iron temperatures are available, although more costly. The tubing should be clear or colored for easy identification
5. A 3/4-in (18-mm) long piece of heat shrink or elastic tubing is fitted over the end of the jacket so that one half lies on the jacket and the other on the twisted pair and the drain wire tubing. The drain wire tubing should be held in place with more than 1/8 in (3 mm) of drain wire exposed at the end. Once installed, the tubing should be firmly in place and unable to slide unless forced
6. The drain wire is trimmed so that 1/8 in (3 mm) protrudes from the tubing fitted in step 4
7. The twisted pair of conductors are trimmed slightly longer than the drain wire to place any tension in the cable on the drain wire
8. The pair of conductors have 1/8 in (3 mm) (typical) of insulation removed. See Section 15.7
9. Tin all exposed conductors if they are to be soldered

Steps 1 through 9 result in a cable with the least chance for failure or intermittence, as there is a minimum of exposed conductors and shield. It is suitable for connection to almost any connector, be it solder, crimp, screw terminals, or insulation displacement and single or multiconductor cable. In some situations longer wire leads may be required although these unshielded leads should be kept to 0.75 in (19 mm) if possible—especially in microphone level cables. Note that the unshielded and untwisted portion of the cable, even though inside the connector shell, is prone to EMI pickup.

Courtesy of Phil Giddings, *Audio System Design and Installation*

Review of "Audio System Design and Installation"

Philip Giddings has written a book entitled *Audio System Design and Installation.*

Let me say up front that it is a good worthwhile book; then, let me get the negatives out of the way first.

The author makes the usual mistakes about the dBm and the Vu (just why is hard for us to understand, as he is a Syn-Aud-Con grad and quotes the applicable standards and then goes on to make the mistakes anyway).

For instance, "dBm(Z). The small m stands for 1mw (milliwatt) while the (Z), often omitted, is the impedance of the circuit measured. When (Z) is omitted, it is assumed to be 600Ω." This kind of error stems from thinking of the dBm as a voltage.

When Giddings comes to the Vu he states "Zero Vu equals +8dBm for broadcast and -10dBV for consumer and semi-professional useage." Really?

Having had my say about these flaws let me continue by saying that I have found other portions of the book a very useful compilation of hard-to-accumulate data.

The section "Cables, Connectors, and Wiring" with its sections on "Wire and cable construction," "Wire and cable for audio," and "Cable preparation" are alone well worth the price of the book.

The contents include:
Power and Ground Systems
Interconnection
Cables Connectors and Wiring
Housing Electronic Equipment

The book is well written and easy to read with excellent illustrations. It is published by Sams at $60 and it is a quality hardback edition of 573 pages.

Thoughts on Measurement

An individual's ability to remember facts is the sign of a conscious being. To organize and catalog large amounts of data is the sign of a thinking being. Deriving new facts signals that the individual is a scientific being.

The Scientific Method

The scientific method starts with the available pertinent facts.

In processing the available facts, cataloging them, and studying them, the scientific being will gradually construct a hypothesis regarding the rules governing these facts.

The hypothesis is a belief that you truly have some knowledge of cause and effect regarding these particular facts. Observation of these facts has led to some ability to predict likely outcomes from use of these facts.

The above eventually leads the scientific being to theorize. That is, if I do this-then that should occur.

At that point experimentation is useful. I'll try this and see if that occurs.

Finally, if that does occur, then you have additional available pertinent facts that you didn't have before and science has been made manifest.

Thinking can be categorized into:

1. Inductive
2. Deductive
3. Intuitive
4. Emperical

Further, we all know that you could go from available pertinent facts to new derived facts via:

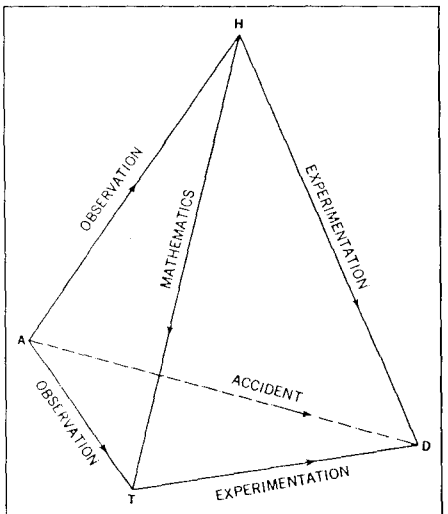
1. Accident
2. Observation plus experimentation

Intuition allows observation of available facts to conceive a hypothesis. Intuition and deduction father, usually via mathematics, a theory. Finally, from theory and experimentation we deduce new facts. See box.

Two helpful roadmaps

Two of the most powerful aids to scientific analysis (remember the analysis goes on in the human mind, not the machinery) are the TEF20 and the Ariel SYSid dual channel FFT. The two "roadmaps" reproduced here give an idea of how one might "observe" available facts relative to a sound system and/or an acoustic environment.

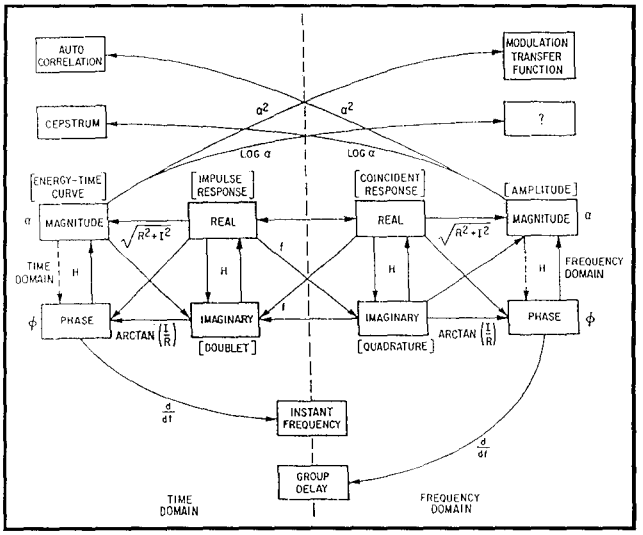
Study them, ponder them, these are todays basics. When you've mastered them, stay humble because you can still get in lots of trouble just correctly interconnecting these marvelous tools to an existing system. But, that's a future subject.

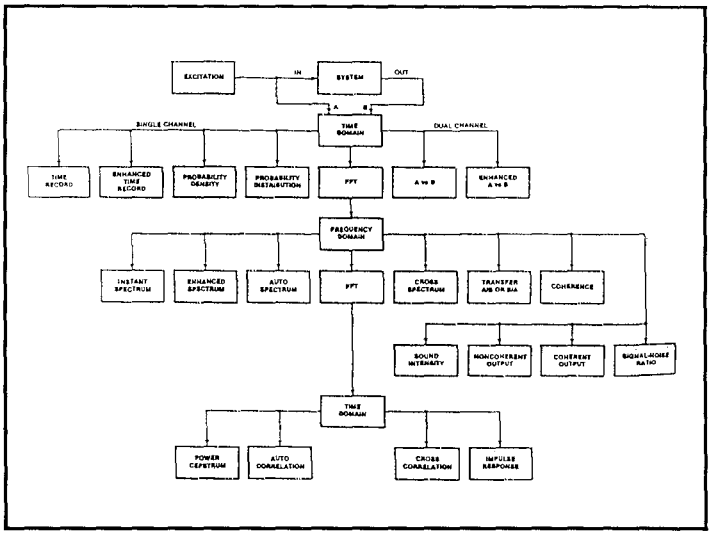


RESEARCH TETRAHEDRON. Arrows show direction of normal progress from available to derived facts. Relative probabilities of successful passage from one vertex to another vary widely; the path AHTD is most likely.

The faces of the Tetrahedron are:
AHT pure induction
DHT pure deduction
ADT Intuitive
ADH Emperical

Where A is available facts
H is hypothesis
T is theory
D is new derived facts





サウンドシステム エンジニアリング

ドン・デイビス / キャロライン・デイビス 共著
工学博士 進藤武男 訳

That's *Sound System Engineering* in Japanese. The translation of our book was done by Dr. Takeo Shindo (L) of TOA. TOA President, Shigeo Fujioka authorized this Japanese edition as part of TOA's fiftieth anniversary.

We are, of course, pleased to be so honored and to have the book made accessible to so many more people.

We were unable to attend the publication party in person, but we were, as you can see, there in photographic form. The picture of us had been taken during our visit to TOA's Kobe headquarters in 1991.

The Syn-Aud-Con "Mind Set"

It is axiomatic that in conflicts we "fight with our mind." Humans display either the flight or fight mind set when startled.

It is also true that all real learning goes on in the deep recesses of the human mind. When challenged by the wealth of information that they should know but don't, Syn-Aud-Con basic class students have two choices—fight or flight. The vast majority choose fight. Flight manifests itself in total unwillingness to try and think a problem through. Fight is manifested by question after question until the individuals personal light bulb glows with an understanding of the problem at hand.

What we have to share at Syn-Aud-Con are the most efficient ways to solve audio and acoustic problems. We don't say that what we share is the only way but we will defend that it is indeed the most coherent and efficient way.

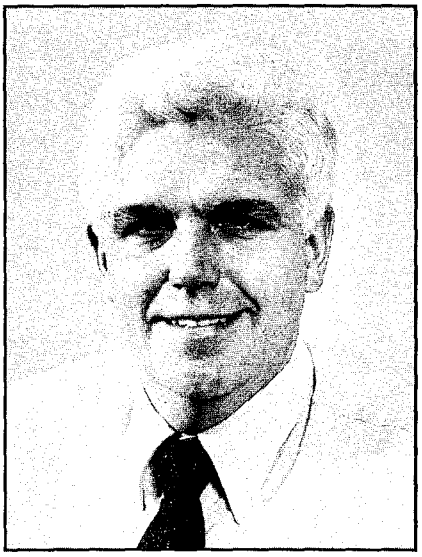
Because the vast majority of those who come to the farm already are professionals in our industry they already know how much there is to learn and they are less startled than most when new challenges are presented. Venturing into the river of knowledge is always exciting and can, on occasion, seem overwhelming. All of us engaged in teaching, sharing, or motivating know that in the words of the old folk song, "You've got to cross that lonesome river. You've got to cross it by yourself. There ain't no one can cross it for you."

What we try to do to help you get in the swim is to identify where the whirlpools are, what the rapids and waterfalls act like, and help you keep in the main current going where we'd like to see you safely arrive.

Sound too dramatic! Well, brain death is as painful for the observer to watch as physical death. For the past twenty, full to bursting, years we have succeeded with a majority of those who entrusted themselves to our program. As we continue we do so with the additional experience of these twenty years because we too have had to "grow or go" and we still, albeit painfully, do our mental pushups in order to maintain ourselves as humble seekers of the truth as best we can understand it.

Earned Advancements at Shure Brothers

It is always with extreme pleasure that we hear of the progress of men and women deserving of recognition. The three men shown here we have known and respected for nearly twenty years. Each has on occasion helped us understand better ways to do familiar things. It speaks volumes about a company that selects, nurtures, and rewards men of this caliber. Shure is a remarkable company. There is no higher compliment we can pay a company's leadership than to realize the longevity and growth of these three men within a successful American business enterprise.



William R. Bevan has been promoted to Vice President, Research and Development

Shure has announced the promotion of Bernie Jakobs to Senior Vice President, Engineering

John F. Phelan has been promoted to the position of General Manager, International Marketing and Sales

Power Politics

Don has found a fellow spirit. Let's quit foooling around and not talk to people who can't discuss level in dBm. Volt and watt are herein defined as four letter words.

Watts?

Dear **RW**:

Re: "Daytimers Face Low Power" (RW, 15 November), I refuse to discuss signal levels and powers with anyone who cannot think of power in "comparative decibels."

If they quote *watts* to me, I ask them, "How much is that in dB?"

If they do not have an answer, I break off right there.

George Bonadio
Watertown, NY

RW *replies: Good point.*

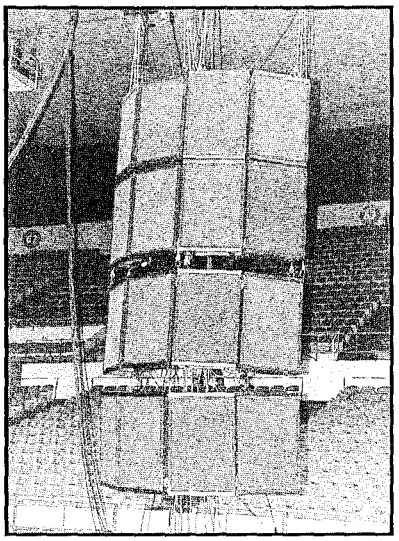
From Radio World, January 1, 1986

ATM Fly-Ware
An Idea Whose Time Has Come

Andy Martin attended his first Syn-Aud-Con class in 1988 and has attended many seminars and workshops since then, so it is natural that we follow his work closely.

In 1990, Andy and his company gave a demonstration at the Renkus- Heinz Conference of a product that he had developed out of necessity—hardware for suspending loudspeakers and loudspeaker arrays.

We appreciated the importance of what he was doing and offered to find distribution for his product. Andy felt that he could do it on his own and that he has! He has been very successful. Andy is offering to give you, free of charge, the manual he has written, *Safety Handbook and Rigging Reference Manual.*



His letter with all the pertinent details is reproduced here.

ATM GROUP

ATM GROUP ▪ 20960 Brant Avenue ▪ Carson, CA 90810 ▪ 310 639 8282 ▪ 310 639 8284

December 21, 1992

Synergetic Audio Concepts
12370 W. Co. Rd. 100 N
Norman, IN 47264

Attn: Carolyn Davis

Re: Safety Handbook and Rigging Reference Manual

Dear Carolyn,

Please let all the Syn-Aud-Con supporters and graduates know that ATM Fly-Ware is happy to send to them the "Safety Handbook and Rigging Reference Manual" free of charge. All they have to do is request the rigging safety manual via telephone, fax, or letter to:

ATM Fly-Ware
20960 Brant Avenue
Carson, CA 90810
310.639.8282
fax 310.639.8284

The "Safety Handbook and Rigging Reference Manual" is designed as an aid for suspending loudspeakers and loudspeaker arrays: however it also contains useful information for other rigging applications.

ATM Fly-Ware is committed to safety and continues an on-going educational safety program as one of the company's motivating forces. ATM Fly-Ware offers literature as well as guest speaking and workshop instruction in order to help educate and support the professional audio industries in the hopes of perpetuating a safety conscious and informed professional rigging community.

Thank you for your support, and keep up the good work at Syn-Aud-Con.

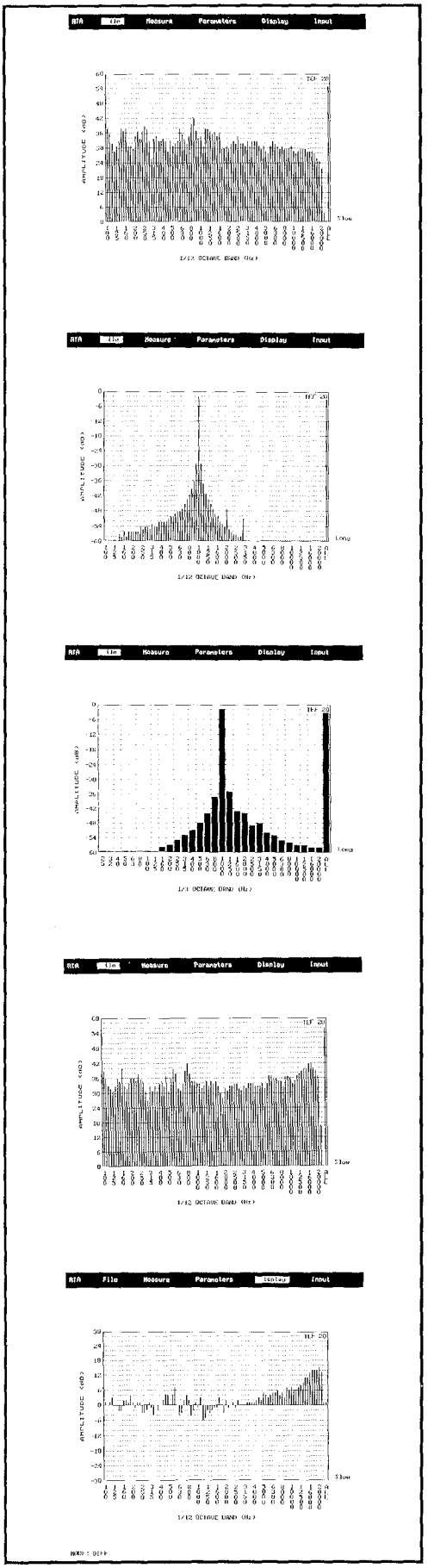
Best regards,

Andrew T. Martin, President
ATM Fly-Ware

Patronis Health Club

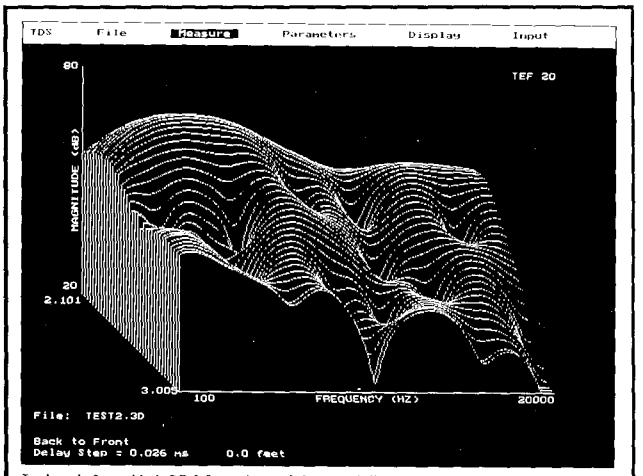
If you've noticed recent pictures of Gene Patronis looking fitter and trimmer, it's because of the problem shown here. He's also sharpening up his shooting skills and he may be getting ready to try a Jim Carey remedy called laying a .45 on the table and saying, "You don't mind if I smoke do you!"

Jim visited his dentist, laid his .45 on the dentist table next to the chair and said, "We're not going to hurt each other are we?"



TEF-20 Update Report

The TEF-20 team in Elkhart, IN continues to inundate us with new and better ways to look at audio and acoustic systems.



Techron's Sound Lab PC 1.3 produces 3-D waterfall displays which can be viewed from a left or right perspective and from the front or back. This illustration shows the first three milliseconds of decay of a speaker with the frequency axis in hertz, the amplitude axis in dB, and the time axis in milliseconds

3D Measurements

The TEF-20 now does 3D measurements. Most people use such measurements to look at the joint time-frequency domain behavior of systems where the horizontal axis is frequency, the vertical axis is level, and the oblique axis is time. It can also be used where the oblique axis is the angular rotation of a loudspeaker or microphone. In fact, what you use the three axis for is limited only by your imagination. With the dynamic range offered by the TEF-20 your imagination is allowed a much wider horizon than the older TEF 10 & 12s provided. Note in the illustration a good useable 60 dB is available on the screen.

Real Time Analysis

Farrel Becker now has the TEF-20 RTA doing 1/1, 1/2, 1/3, 1/6, and 1/12th octave analysis. In the 1/12th octave mode you can see -50 dB down 2nd harmonics (i.e. 0.316%). Slow, medium, and fast integration times and multiple memory as well as choice of display (bars or dashes) are available.

Dieter Michel, a very talented audio engineer and author, wrote a review of the TEF 20 for "Audio Professional," a German publication. We can't read German but did recognize the beauty of his distortion measurements (reproduced here).

Of real importance to us is the dual channel feature that allows us to use the RTA for transfer function measurements. That translates into English as, "I can watch the frequency response of my system in real time with program material as a test source." Mind you, not the frequency response of the program material but the frequency response of the system or, for that matter any chosen part of the system such as the equalizer.

Prediction

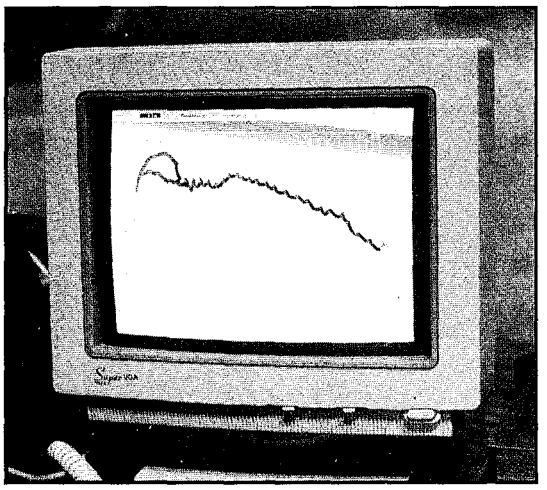
Before 1993 comes to an end, we expect to see a full SDM system that includes:

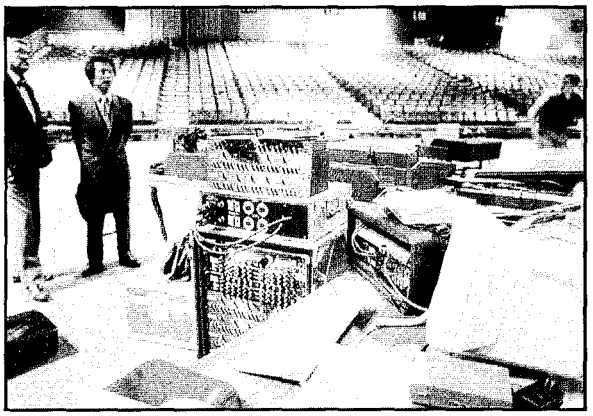
1. Interactive TEF-20 analysis with a fully digital precision filter system.
2. Inverse equalizer curves synchronized with house curve.
3. Full preview of EQ bandwidth, depth, frequency, and phase followed by instant, silent insertion into system.

Bass Build Up From a Focusing Corner— Should It Be Equalized?

We visited Jim Hammond of Stage II in Indianapolis during his set up for a big show in Indiana Convention Center. He was going to use the new Altec AcoustaEQ and we wanted to hear how it was going, but we got there too soon. Jim had just hoisted the loudspeakers into position and hooked them up and was playing them unequalized when we walked in.

We showed him how we were using the B&K 4007 microphones like a PZM™ for measurements and put the microphone on the floor on axis with one of the loudspeakers in the array. There was a huge bass rise in the low frequencies - and we heard it when we arrived. John Murray of TOA was with us and he said, "I'll bet it is the corner." and promptly sacrificed his body on the floor between the microphone and the corner. Volla - the bass rise was gone, in the measurement, that is.





Jim didn't have his printer set up, but I had my camera with me and took pictures, which didn't come out very well so I inked in over the measurements to make them clearer. Hopefully the original measurement will show through.

Had Jim not identified what was causing the bass rise he might have equalized out the bass in that position only to have a bass deficiency in other seats - or why it is important to determine whether we are equalizing direct sound or reflections. Remember Dr. Patronis' Poles and Zeros paper?

cd

Does Grill Cloth, Which Causes a Reflection 15 dB Down, Affect the Direct Sound?

'Yu dam betcha!'

Don't you often hear people say something to the effect that since a reflection is down 10 dB or more that it doesn't affect the direct sound. I have heard Dr. D'Antonio say that reflections down 18 dB can affect the direct sound.

Look at the ETC and EFC measurements made by Don Keele of a loudspeaker with and without the grill cloth. The reflection from the grill cloth is approximately 15 dB down and look how it has affected the direct sound starting at 2,000Hz. If we looked at the measurement on a linear scale, it would look much more dramatic since the region from 3,000 - 6,000 Hz is affected to the tune of 10 dB.

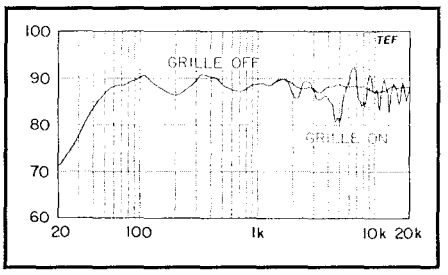


Fig. 1-Anechoic frequency response

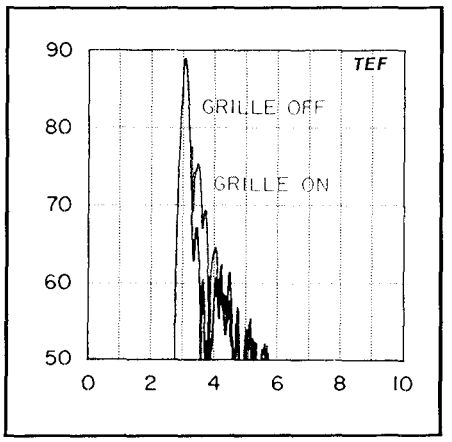


Fig. 2-Energy/time response

Guiding Light

Someone at the 1992 JBL Conference quoted Marsha Sinetar. I failed to jot down the name, but it is worth repeating here.

"Do what you love and the money will follow," which made me think of a similar statement from the Bible: "Seek ye first the Kingdom of God and all these things shall be added unto you."

EASE UPDATE

Carl Dorwaldt of Renkus-Heinz in Irvine, CA talked with us recently regarding the progress of EASE, EASE JR, and EARS.

Renkus-Heinz will introduce both EASE 2.0 and EARS at the Berlin AES Conference in March. EARS is a *binaural* software auralization program intended for use with version 2.0 of EASE.

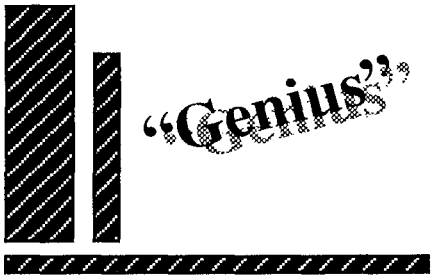
Version 2.0 of EASE will feature:

1. Signal directivity information in the simulation routine
2. DXF data transfer capabilities
3. Window-like pull down menus
4. A newer room modelling method
5. Improved graphics
6. Additional print drivers
7. The ability to handle non-symmetrical loudspeaker data

EARS is a Binaural Auralization system that includes both right and left ear transfer functions as measured by Blauert and Lehnert at Bochum, Germany.

March is not that far away and we already have experienced the improvement that incorporating ear transfer functions makes in the auralization. EARS is eagerly awaited.

October Farm Seminar



Richard Feynman as a very young man played a key role in making the first atomic bombs. Oppenheimer wrote a colleague at Berkeley about Feynman saying, "He is not only an extremely brilliant theorist, but a man of the greatest robustness responsibility and warmth, a brilliant and lucid teacher. We regard him as invaluable here; (Los Alamos) he has been given a responsibility and his work carries a weight far beyond his years."

Feynman in his last years, dying of cancer, sat on the presidential commission on the space shuttle accident and using a 'C' clamp and a glass of ice water demonstrated the physics behind the 'O' ring failure that had caused the disaster.

James Gleick has authored a very readable and useful biography of Feynman entitled appropriately "Genius."

Freeman J. Dyson's review of the book in *Physics Today* affirms our judgment of the book's worth and quotes Gleick's insight into Feynman's mind set, "Feynman believed in the primacy of doubt, not as a blemish upon our ability to know, but as the essence of knowing."

I've only personally known one authentic genius, Dick Heyser. Both Dick Heyser and Dick Feynman (they knew each other at Cal Tech) could do a remarkable amount of math in their heads. During the atomic bomb project, Feynman would get telephone calls from fellow workers asking questions like, "What is the sum of the series $1+(1/2)^4 + (1/3)^4 + (1/4)^4 + \ldots$

To which Feynman instantly replied, "How accurate do you want it?" The party calling replied, "One percent would be fine." Feynman snapped back, "1.08." He had simply added the first four terms in his head and that was enough for two decimal places.

Then his caller asked for the exact answer, "You don't need the exact answer." Feynman replied.

"Yeah, but I know it can be done."

So Feynman told him, "All right." "It's pi to the fourth power over ninety."

From that kind of thinking it's not hard to imagine that Feynman did indeed "sometimes terrorize his students." (Freshman physics students at Cal Tech.) A witness to his classes has written, "As the course wore on, attendance by the kids started dropping alarmingly, but at the same time, more and more faculty and graduate students started attending; so the room stayed full, and Feynman may never have known he was losing his intended audience."

Feynman once told a colleague, "Scientist are explorers and philosophers are tourists. The tourists like to find everything tidy; the explorers take nature as they find her."

I highly recommend this book as one which will provide you a glimpse of a great scientist with staggering personal problems who earned a Nobel Prize on his own terms. It is a book that lifts the reader out of the everyday humdrum of turned off people.

For Sale: TEF-10 upgraded to 12+, like new with all TEF tools software—$4,000. Contact Bill Lipis at 619-448-6064.

Available: Recent graduate with BS in Electrical Engineering (5/92) and has passed the Engineering-in-Training Exam. Skilled in computer languages and use of the computer. Senior electives in data communications, digital design and programmable logics controller. Currently employed but would like to work in audio. Would like an entry level engineering position that utilizes electrical and engineering education and work experience. Contact Scott D. Jackson, 8023 Eastern Ave, Apt. 311, Silver Spring, MD 20910. (301) 589-4660.

Wanted: Megan, an 8 year old neighbor of ours, would like to have a PC computer. She has saved $300. If you have a 286 with EGA monitor for sale, please let her know. Or if you have a 386 with VGA monitor that you are willing to sell, let us know what you would take for it. Megan can get a loan as she wants a computer very much and is willing to work for it. You can contact us here at Syn-Aud-Con. 812-995-8212 or fax 812-995-2110.

Employment Opportunity: Columbia College Chicago invites applications for a full-time Radio/Sound faculty member beginning February 1, 1993. Responsibilities include teaching 12 hours in audio related areas, advising students and developing curriculum in Recording and Studio Maintenance or Sound Contracting and System Design. A BS/BA should be combined with ten years in professional audio. Experience should include extensive recording studio administration or sound system design preferably with CAD Syn-Aud-Con Grad desired. Teaching experience essential. Computer programming skills a plus. We offer a competitive salary with excellent benefits. Minority and women applicants are especially encouraged to apply. Submit letter of application and resume to Radio/Sound Search, Human Resources Department, Columbia College, 600 S. Michigan Ave., Chicago, IL 60605. EOE M/F/D/V

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Acoustical Consultants may list their cards on this page. There is no charge. The only requirements are that you are a full-time consultant, that you have attended a Syn-Aud-Con seminar, and have an active subscription to the Syn-Aud-Con Newsletter. If you would like to be on our Consultants page, send in four (4) business cards for our file.

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Pistol shooters Only

I have been shooting pistols for nearly sixty years and enjoy firearms of all types. While well trained by a Marine father in terms of safety and marksmanship, I had never been subjected to proper rapid weapon handling in stress situations. About five years ago, I attended the American Pistol Institute basic training course at the famous Gunsite Ranch under the tutelage of Col. Jeff Cooper. One thing led to another namely the advanced course, the instructors course, and lots of shooting exposure at Gunsite annual shootouts, etc.

Late in November, I fulfilled my commitment as a provost coach at Gunsite in a class attended by Jim Carey and his son, Mike. This is the Sig/Synch Jim Carey. In the course of six days and 600 rounds of 45 ACP each, they did themselves proud. Young Mike defeated a series of Marine Corp. pistol experts from Camp Lejune to take fourth place and Jim outshot a 22-year old veteran of the Corp., and Master Gunnery Sergeant to boot, during the class man-to-man shootout.

Normal Gunsite classes have attendees from places like Seal Team 5, Quantico Marine Base, DEA, U.S. Border Patrol, Dept. of Justice, and a myriad of police organizations with occasional civilians salted in.

Really good shots can come unglued when experiencing the combat simulators which include both indoor and outdoor stress situations.

As Carolyn put it after taking the course, "If one is going to own a gun, they should have this kind of training in its use."

All of the above made us receptive to Jim Carey's suggestion of, "Wouldn't it be great to have a full class of Syn-Aud-Con grads for a Gunsite class." We'd like to hear from any of you that would be interested in participating in such a special class. The cost is $700 per student, ammunition costs approximately $300 and all meals, hotel, travel etc. at your expense. A full Gunsite class consists of 24 students and lasts five and one-half days. (Mon. through Sat. noon) Preferred weapons are Semi automatic pistols or revolvers in calibers of 38 special up with 45 ACP and 9mm being the most often used.

Dates we are considering are the fall of 1993 (late Sept.-Oct.) or early 1994 (April-May). If you have a genuine interest in such training and in the opportunity to be coached by Col. Jeff Cooper and his exceptional staff, let us know. If sufficient interest is evidenced, we will undertake having such a class scheduled.

Mike Carey

International Pistol Craft

While the farm has a 100 meter well equipped pistol range, no shooting is ever engaged in during a Syn-Aud-Con class or workshop. When special guests are at the farm after a class and indicate a desire to do so, we all enjoy the shooting range.

In this case, we had an international group of Glock 21 shooters from Dr. Wolfgang Ahnert from Germany, Peter Mapp from England and Harro Heinz from the U.S. by way of Germany.

Here we are checking reaction time - the time between the sound of the buzzer and the pistol fired from a ready position. (Dr. Ahnert "won" with a reaction time of .16 seconds.)

Note how well Harro controlled the recoil of the full house 45 ACP. The pistol is in full recoil.

Highly interesting to us is the fact that all three of these men have in abundance the qualities necessary to success in any enterprise, discipline and concentration.

SYN-AUD-CON SPONSORS

Syn-Aud-Con receives tangible support from the audio industry. Nineteen manufacturing firms presently help underwrite the expense of providing sound engineering seminars. Such support makes it possible to provide the very latest in audio technology while maintaining reasonable prices relative to today's economy and to provide all the materials and continuing support to all graduates of Syn-Aud-Con.

Personnel from these manufacturers receive Syn-Aud-Con training which provides still another link in the communications circuit between the ultimate user and the designer-manufacturer of audio equipment. They are "in tune" with what a Syn-Aud-Con grad needs.

Their presence on this list as a Syn-Aud-Con sponsor indicates their desire to work cooperatively with you in professional sound.

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No.1 to Syn-Aud-Con
Newsletter Vol. 20 No. 2

Fractals and Number Theory are Changing the Shape of Acoustics

I know of no individual who has done as much for the acoustic treatment of rooms in our lifetime as Dr. Peter D'Antonio. He has provided theory, design, and application information and practices to a degree matched only be the founder of architectural acoustics, Wallace Clement Sabine back at the turn of the centry.

We have repeatedly noted Peter's remarkable energy output in being able to successfully handle both his scientific work for Naval Research and his unparalleled achievements in founding and developing RPG Diffusor Systems, Inc. Being pat of the American dream is helped by God's gift of an active mind coupled to the ability to fall in love with a neglected technology and solve its problems.

Thanks to Peter, we now have a full tool box for dealing with both large and small room acoustics.

We are reprinting this article from Sound & Vibration, Octoaber 1992 issue as the most concise, yet complete, review of Peter's accomplishments in the past ten years. Study the article; it is important to your future in the audio industry.

Reprinted by permission from Sound & Vibration, October 1992

Fractals and Number Theory are Changing the Shape of Acoustics

Peter D'Antonio, RPG Diffusor Systems, Inc., Upper Marlboro, Maryland

A new generation of acoustical materials derived from the unlikely scientific disciplines of mathematical number theory and fractals are expanding the conventional passive acoustical palette of design ingredients. These new sound diffusing, absorbing and variable acoustics elements are providing architects, acoustical consultants, designers and sound contractors new tools to provide noise control and sound control in all commercial listening and performance environments, as well as in home theaters and listening rooms. These new ingredients are finding widespread application, because they offer a balanced acoustical design that does not rely on absorption alone. In addition, the determination of the directional scattering coefficient of these and other conventional materials will soon make it possible to auralize the behavior of a space in the design stages.

The sound that we hear in a room is a combination of the direct sound emitted by a source and the indirect reflections from the room boundaries. The indirect reflections arrive at a given point at discrete times which are related to their travel paths. The amplitude, arrival time, temporal distribution and directionality of these indirect reflections determine how we perceive the actual sound source. Thus, control of room reflections is a central consideration in architectural acoustic design. Room reflections can be controlled by the application of surface treatments that absorb, reflect or diffuse the incident sound. Sound is attenuated by absorption, redirected by reflection and uniformly distributed by diffusion. Figure 1 illustrates how sound is modified in the space and time domain by these three acoustical surface treatments.

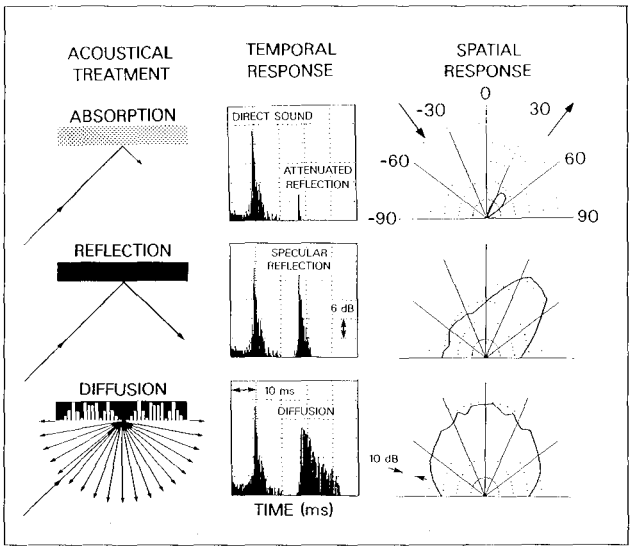


Figure 1. Comparison of the spatiotemporal properties of acoustical treatments.

The Acoustic Palette

Absorption. Absorption is the most familiar sound modifying treatment and the one most commonly specified. In fact, the term "acoustical material" has almost become synonymous with absorptive ceiling tile, fabric covered glass fiber or rockwool, foam, bonded wood fibers, etc. Such a heavy reliance on absorption is unfortunate because absorption, while an important ingredient, is not the only acoustical treatment and for many applications it is the *wrong* ingredient.

The efficiency of an absorbing surface is rated by the absorption coefficient, which indicates the percentage of randomly incident sound that is absorbed. An ideal absorbing surface, determined according to ANSI/ASTM standards, has an absorption coefficient of 1.0 for random incidence sound for all frequencies in the audio spectrum. While these random incidence absorption coefficients are useful in statistical calculations of the reverberation time, for reflection control we have advocated for the adoption of a frequency-dependent *directional absorption coefficient*, that can completely characterize the polar response of the material. This parameter indicates the percentage of sound absorbed as a function of the frequency, angle of incidence and observation direction. A plot of these coefficients, for a particular frequency band and angle of incidence, forms the polar response of a scattering surface. This is indicated in Figure 1 by the small outgoing sound arrow in the upper left diagram and the "attenuated reflection" in the temporal and spatial responses. RPG Diffusor Systems has begun a program to experimentally characterize the polar response of all sound modifying surfaces and encourages the *directional scattering coefficient* as an ASTM standard.

Examples of absorbing surfaces which are effective for directional as well as random incidence are shown in Figure 2. The Abffusor®, Figure 2A, as its name implies is a patented surface which attenuates sound by both absorption and diffusion. The Absorbor™, Figure 2B, is a fabric upholstered graduated-density fiberglass GDF™ panel. The density and impedance increase as sound enters the panel. The porous surface layer is effective for glancing incidence and the progressively denser and thicker interior and backing are effective for lower frequencies. The 18 and 20 lb/ft^3 laminated high density tackable fiberglass panels should not be used for reflection control since they are too reflective. RPG has recently introduced the concept of Total Room Acoustical Conditioning, called Soundtrac™, wherein a special fabric trac fastener system is used to extend the traditional stretch wall approach to provide integrated acoustical interfaces between absorptive, reflective and diffusive surfaces.

Practically all commercial porous absorptive treatments are effective above 500 Hz for random incidence. When using such materials one also should verify the performance below 500 Hz to assure low frequency absorption. Remember that low frequency efficiency increases as the depth of the air space behind the porous absorber is increased. If additional low frequency absorption is required, damped diaphragmatic membrane absorbers, Helmholtz slat resonators, etc. can be specified to augment porous absorbers. A slat resonator mounting of FlutterFree™ hardwood molding panels is shown in Figure 2C.

Reflection. When flat or curved reflective surfaces which are stiff and massive to prevent diaphragmatic absorption and transmission are many times greater than the wavelength of the incident sound, interference effects cause the scattered sound to be redirected and reflected as light from a mirror. This mirror-like reflection usually is referred to as a specular reflection where the angle of incidence equals the angle of reflection. This is illustrated in the middle row of Figure 1 by a longer reflected arrow than in the absorptive case, a "specular reflection" in the temporal response which is comparable in level to the direct sound and by a spatial response that reveals that reflected sound is oriented in the specular direction (45°).

The geometry of a room's reflective boundaries is important

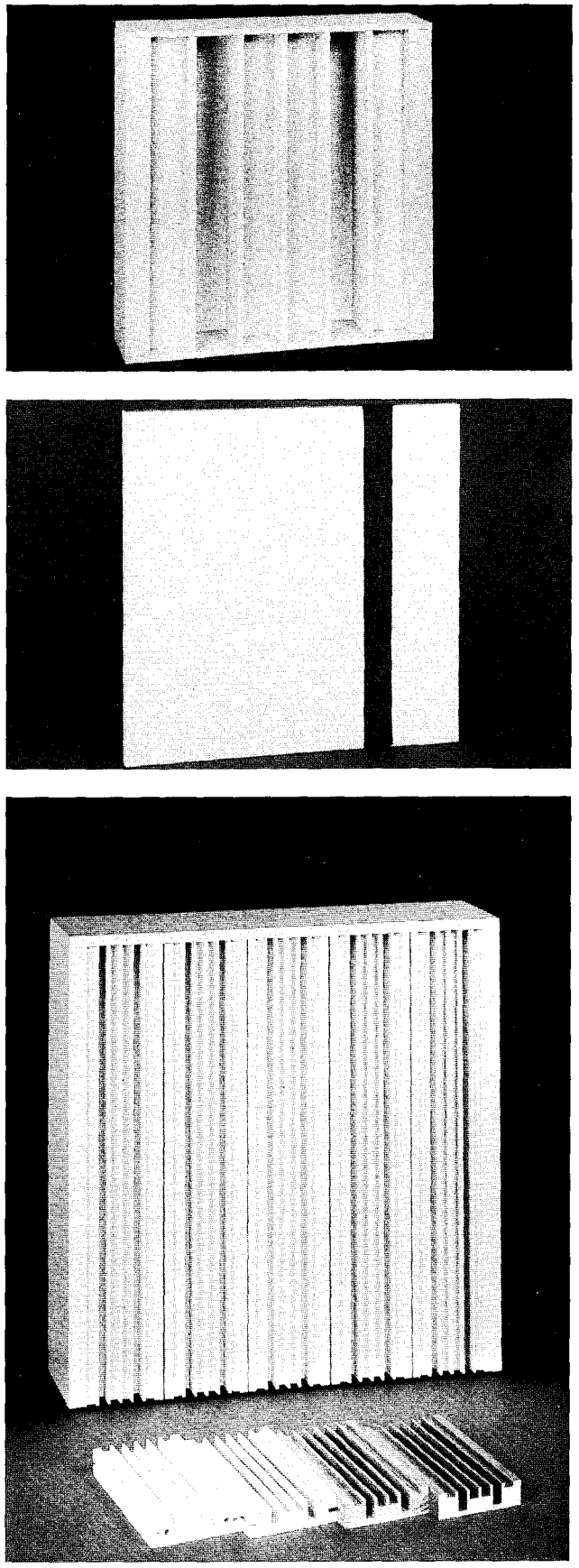


Figure 2. A) Abffusor - a patented fabric upholstered absorption phase grating, that provides reflection control by simultaneously using absorption and diffusion. B) Absorbor - the latest innovation in upholstered graduated-density fiberglass panels with resin-hardened edges. C) FlutterFree - a flutter control hardwood molding in a Helmholtz bass absorber mounting.

in determining the reverberant characteristics of a space. If a reflective surface is concave as unfortunately it is in the rear of many churches, auditoriums and recital halls, scattered sound can actually be intensified or focused at certain positions in the room. Large concave reflective surfaces should be avoided in architectural acoustic design. Convex surfaces on the other hand are beneficial because they distribute or disperse incident sound throughout a room. Reflecting boundaries are needed to reflect or project sound in a certain direction as well as toward other acoustic surfaces. To provide broad-bandwidth reflection control, reflecting surfaces need to be large and non-diaphragmatic. As the cross-sectional area of a reflecting surface becomes smaller, the minimum frequency at which specular reflection can occur is increased, thus causing the bandwidth of specularly reflected sound to decrease.

Diffusion. Diffusion promotes the uniform spatial distribution of continuous sound, increases uniformity in the growth and decay of transient sound and improves the "liveness" (ratio of indirectly reflected sound to direct sound) in a room. In performance facilities, for example, diffusion tends to enhance the natural qualities of speech and music for both performers and listeners.

A diffuse sound field exists in a room when the sound energy is uniform at all points in the room and there is a high concentration of sound waves propagating in all directions with equal probability. Diffusion of sound is increased by objects within a room which scatter propagating sound waves and sound diffusing surface irregularities which scatter sound waves impinging on the room boundaries. Ideal sound diffusing surfaces neither absorb nor reflect sound but rather scatter it evenly into many directions instead of just the specular direction. When the directional distribution of scattered sound is uniform and does not depend on the direction of incident sound, the sound is totally diffuse. The range of frequencies over which a surface is totally diffuse and the temporal distribution of scattered sound also are critical.

Acoustic diffusion occurs when the sizes of the surface variations are comparable to the wavelength of the incident sound. There are many types of conventional diffusive surfaces. We refer to these as partially diffusive because their spatial response depends on the angle of incidence and incident frequency. Picture the intricate interiors of a cathedral or "Old World" concert hall. These spaces usually are appointed with statuary, parapets, balustrades, coffered ceilings, loges, balconies, fluted columns, chandeliers, pilasters and other forms of relief ornamentation. Curved surfaces, polycylindrical columns and irregular geometrical shapes might be used as well.

Limited bandwidth diffusion also can be achieved from walls that do not have surface irregularity but instead have nonuniform impedance. This can be accomplished at high-to-medium frequencies by an irregular distribution of sound absorbing surfaces and at low frequencies by diaphragmatic or resonating panels.

To evaluate sound diffusing surfaces, one considers the uniformity of diffused sound throughout a space (its spatial response), the bandwidth (range of frequencies over which the spatial response is uniform), the randomness and density of any irregularly spaced frequency domain notches (the frequency response), and the density, distribution and breadth of the time domain reflection pattern (the temporal response).

Statuary for example scatters primarily high frequencies effectively over a limited angular range of scattered directions with a limited temporal distribution. Thus statuary presents a very beautiful but limited diffusing surface at substantial cost. Individual scattering elements such as statuary must also be constructively configured.

Curved surfaces with diameters greater than a half-wavelength provide good sound dispersion over a particular frequency range for normal incidence. Groups of cylindrical columns of varying diameters - customarily called polycylindrical columns - have been utilized as a way of extending the bandwidth. In practice however this is difficult to accomplish

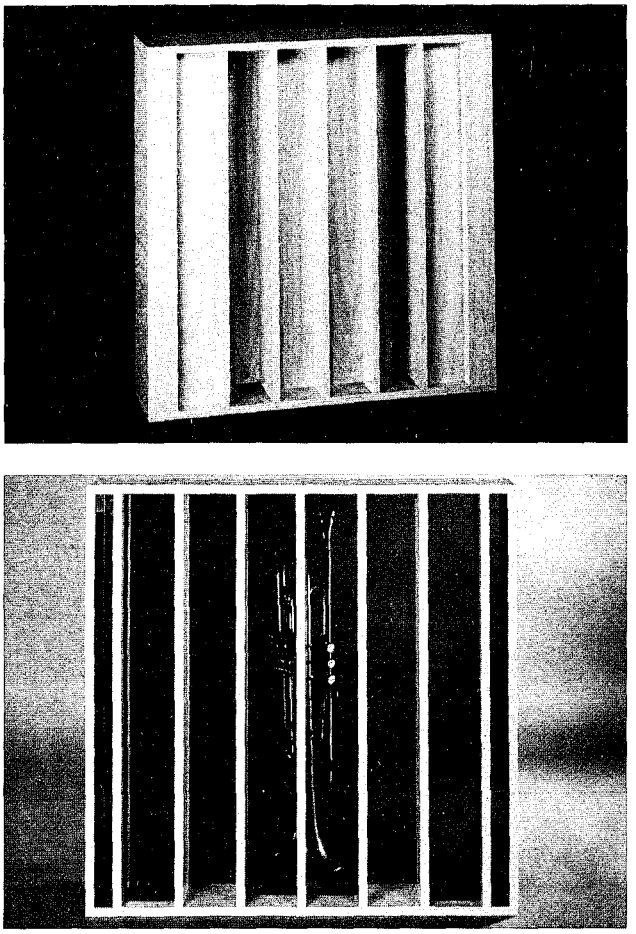


Figure 3. A) QRD Diffusor – a patented broad-bandwidth wide-angle RPG sound diffusor based on quadratic residue number theory sequences. B) Diviewsor – a diffusive panel you can see through when visibility, accent lighting or natural lighting are desired.

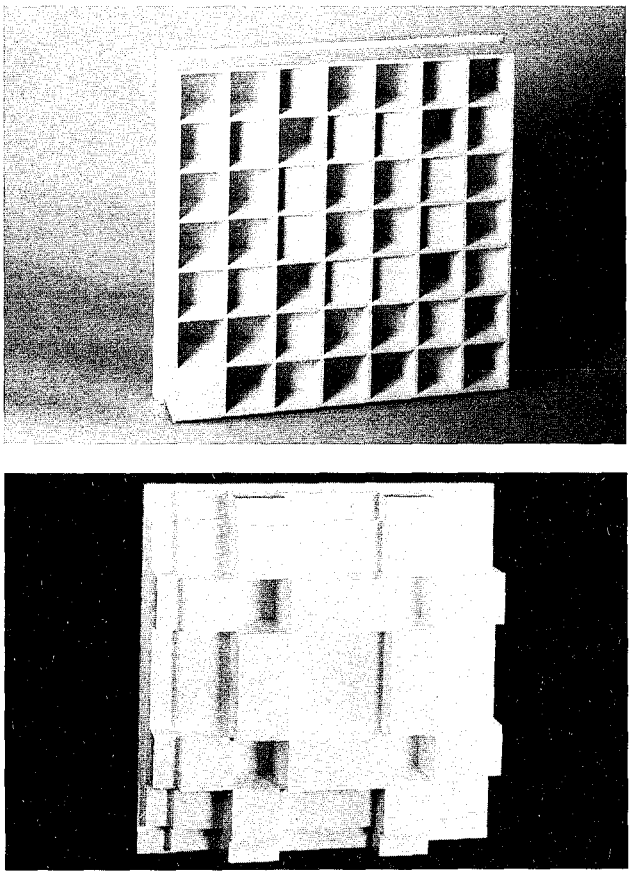


Figure 4. A) Omniffusor – a 2-D QRD Diffusor based on 2-D quadratic residue sequences. B) Terrace – a 2-D QRD Diffusor without wells forming a textured block surface with stepped terraces.

and generally only a few sizes are used. This limits the bandwidth, results in frequency "coloration" and limits the density of the temporal response.

At glancing incidence, monocylinders tend to scatter sound back in the incident direction and polycylinders tend toward specularity. The graph of the frequency response of partially diffusive surfaces is characterized by regularly-spaced "comb filter" notches as opposed to the dense distribution of irregularly spaced frequency notches characteristic of totally diffuse reflections. Despite the usefulness of all of these forms of partially diffuse relief ornamentation, experimental measurements reveal limitations in either the uniformity of the spatial response, the degree of independence from the direction of incident sound, the diffusion bandwidth, the temporal density or the frequency response. Intricate and aesthetic sound-diffusing surfaces, furthermore, are no longer the norm in contemporary architecture. Due to rising building costs and increased seating requirements, flat plaster, concrete, dry wall and cinder block surfaces have become all too commonplace. The result is poor acoustics and an ineffective venue. This presumed economy often leads to expensive acoustical renovation and/or expensive special-purpose sound systems that are called upon to provide an electronic solution for an acoustical problem.

Reflection Phase Gratings

It is reasonable to wonder whether there is an optimum diffusive surface with predictable and calculable results. The answer is yes – the reflection phase grating RPG™. The secret behind its unique properties lies in number theory, the paradigm of pure mathematics. The RPG is an acoustical analog of the optical diffraction grating which has played a central role in optics for more than 100 years. A diffusive surface treatment of this type was not used in architectural acoustics prior to the discovery by Manfred R. Schroeder linking number theory with diffusion and the development of the RPG Diffusor System.

The one-dimensional (1-D) RPG, Figure 3A and 3B, is a modular computer-designed phase grating consisting of a periodic grouping of an array of wells of equal width but varying depths, separated by thin dividers. The proprietary name for an RPG whose depths are based on quadratic-residue number-theory sequences discovered by Karl Friedreich Gauss in the 18th century, is a QRD® Diffusor.

The schematic in the bottom row of Figure 1 illustrates how incoming sound is uniformly backscattered into many directions. The temporal response illustrates how the depth variations of QRD provide attenuated dense diffuse reflections over an appreciable time period compared with direct sound and the spatial response illustrates the wide angle scattering pattern or polar distribution.

The RPG can also be designed in a two-dimensional (2-D) realization. A 2-D diffusor based on a 2-D quadratic residue sequence is called a QRD Omniffusor™, Figure 4A, and consists of a 2-D array of square, rectangular or circular wells of varying depths, separated by thin dividers. Figure 4B shows a "male" embodiment of the Omniffusor called the Terrace™ without cell dividers. It can be seen that the Omniffusor possesses two vertical mirror planes of symmetry and four-fold rotational symmetry. This symmetry insures that the backscattering is identical in both the horizontal and vertical planes. A schematic comparison between the hemidisk coverage pattern of a 1-D QRD Diffusor and the hemispherical coverage pattern of a 2-D QRD Omniffusor is shown in Figures 5A and 5B, respectively. In Figure 5A, the incident plane wave is indicated with arrows arriving at 45° with respect to the surface normal. The radiating arrows touching the hemidisk envelope indicate the dif-

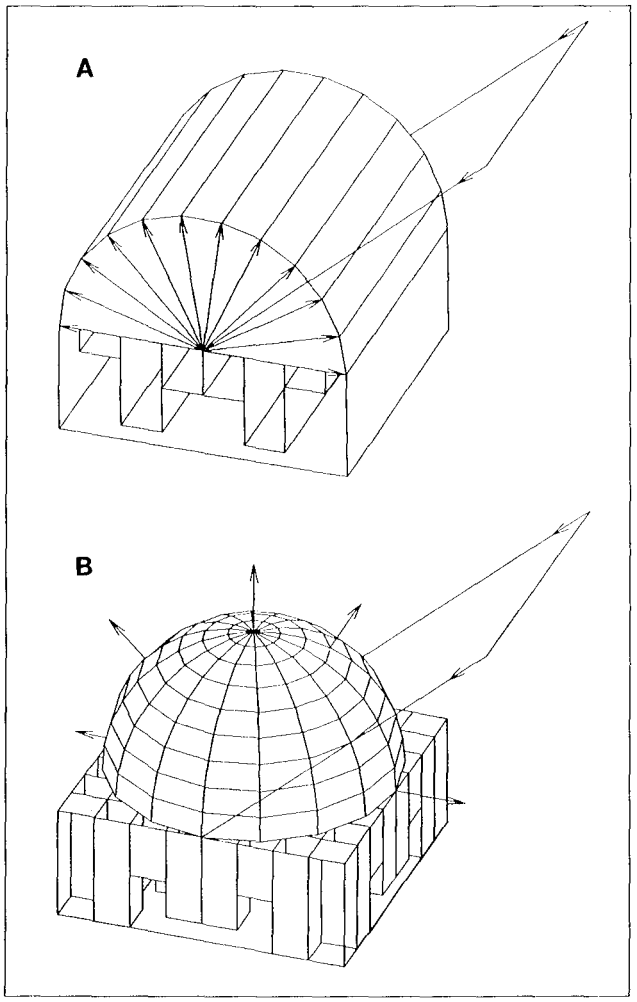


Figure 5. A) Hemidisc scattering pattern from a 1-D QRD Diffusor. B) Hemispherical scattering pattern from a 2-D QRD Diffusor.

fraction directions. In Figure 5B the incident plane wave is indicated with arrows arriving at 45° with respect to the surface normal. The arrows radiating from the hemisphere envelope indicate a few of the many diffraction directions.

The 1-D QRD backscatters sound into a hemidisk which can conveniently be directed by orienting the diffusor or the source. The far-field steady-state energy is proportional to $1/N$ where N is the number of wells in a repeat unit. The 2-D QRD Omniffusor backscatters sound into a hemisphere and the steady-state energy is proportional to $1/N^2$. The steady-state energy at an observation point within the coverage area of a 2-D QRD would be half (in dB) of that observed in the coverage area of a 1-D QRD. The omnidirectional coverage pattern of the 2-D Omniffusor is less controllable than the hemidisk of the 1-D diffusor.

Diffusing Fractals

Benoit Mandelbrot coined the term fractal to describe a shape made of parts similar to the whole in some way. That is, a fractal contains unlimited copies of itself. Fractals offer shapes which more closely approximate natural shapes such as clouds, coastlines, trees, ferns and so on. Many natural shapes are fractals because they look the same regardless of how far you zoom in on them. For example a line that approximates a mile of coastline from an aerial view will look pretty much like one that approximates a foot of the coastline as viewed on earth. A boulder looks a lot like a rock, which looks a lot like a pebble, which looks a lot like a grain of sand, depending on your view.

We have used fractal geometry to develop a complex surface which provides full spectrum diffusion by nesting or combin-

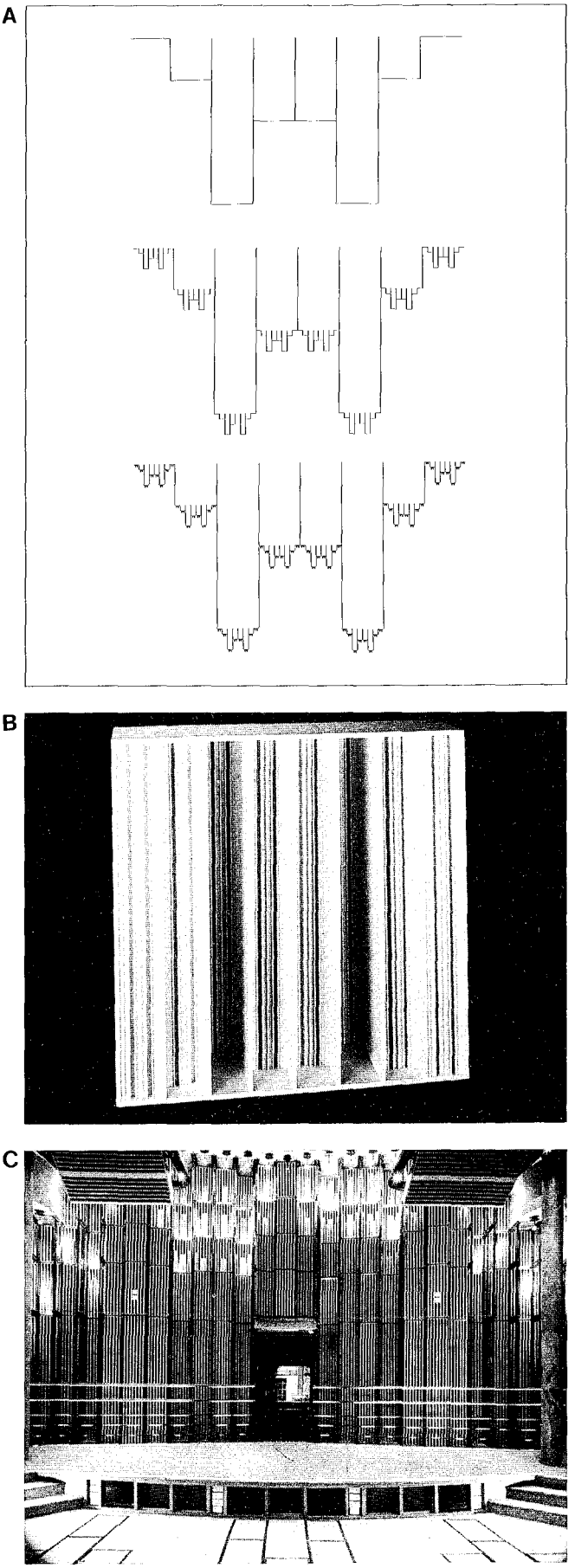


Figure 6. A) Evolution of a Diffractal from a QRD. B) Diffractal - a full-spectrum patented fractal diffusor. C) Diffractal installation at Peter Gabriel's Real World Studios, Bath, England.

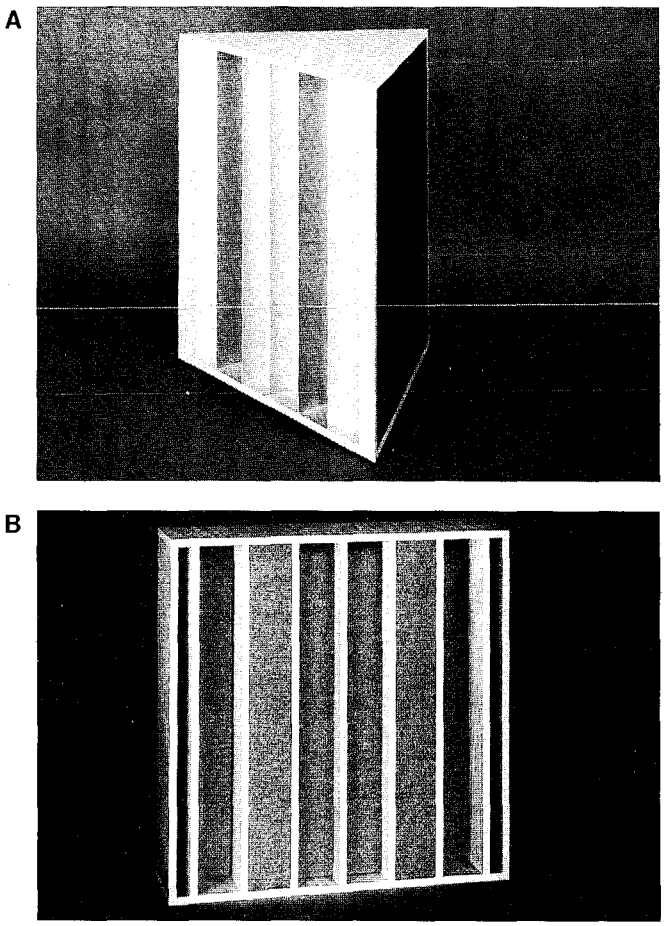


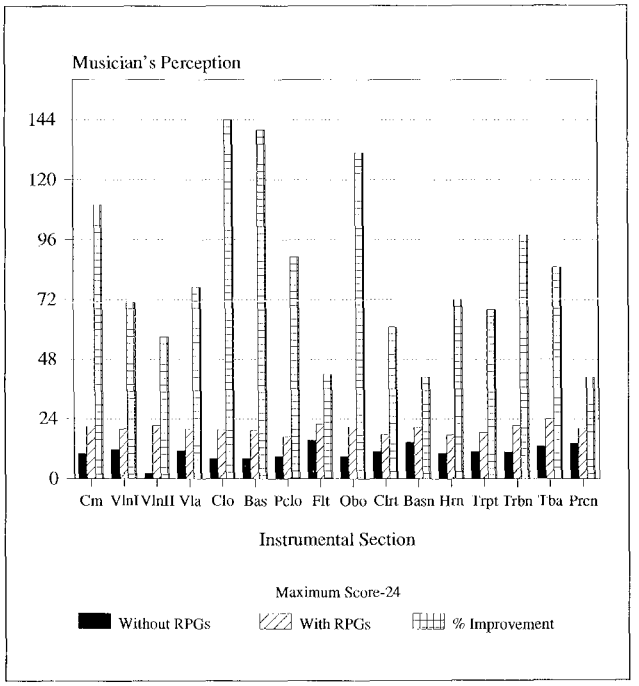
Figure 7. Variable acoustics modules. A) Triffusor - three-sided diffusive, absorptive and reflective rotatable triangular column. B) Biffusor - two-sided diffusive and abffusive rotatable panel.

ing high and low frequency diffusing elements into a hybrid structure. The proprietary name for this surface is a Diffractal® shown in Figure 6. Close examination of Figure 6A reveals that the Diffractal is obtained by replacing the wells (segments between vertical dividers which remain unchanged) with a scaled replica of the QRD yielding a diffusor within a diffusor. The Diffractal, Figure 6B, is analogous to a crossed-over two-way loudspeaker where each transducer or diffusor covers a particular frequency range. The two diffusors are essentially independent in performance because low frequency wavelengths are unaware of the surface irregularity of the HFD and the quadratic phase changes introduced by the LFD do not affect the polar distribution of the HFD. Figure 6C illustrates an application at Peter Gabriel's Real World Studios, Bath, England.

Variable Acoustics

Because we all change our minds occasionally and it makes economic as well as functional sense to have a versatile acoustical environment, RPG has developed a line of variable acoustics modules, Figure 7. The Triffusor™ (Figure 7A), like the Greek periaktoi, is a three-sided rotatable triangular column containing QRD diffusive, absorptive and reflective sides, providing unlimited flexibility and adaptability to changing acoustical needs. The Biffusor™, Figure 7B, is a two-sided variable acoustics module offering a choice between QRD Diffusion and Abffusion.

Several years ago RPG Diffusor Systems established a performance acoustics research program in conjunction with Telarc and the Cleveland Institute of Music to determine the appropriate combination and orientation of reflecting, diffusing and absorbing surfaces to optimize performance using objective measures as well as musician's perceptual evaluations. The results of one of these investigations with the Baltimore Symphony Orchestra is presented in Figure 8A. This case study was carried out at the Meyerhoff Symphony Hall, Baltimore, MD. Musicians of the BSO were asked to compare the existing stage with the same stage after the addition of the RPG Variable Acoustic Modular Performance Shell (VAMPS™ acoustical shell), Figure 8B. Their preferences concerning ability to play in synchronicity, ease of tone production, intonation and ease of ensemble were solicited on a scale of 1 to 4. The % improvement is indicated by the ratio of the total score with VAMPS divided by the total score without. The results clearly indicate the orchestra's overwhelming preference for the VAMPS acoustical shell with an average improvement of 83% and a maximum improvement of 144%.



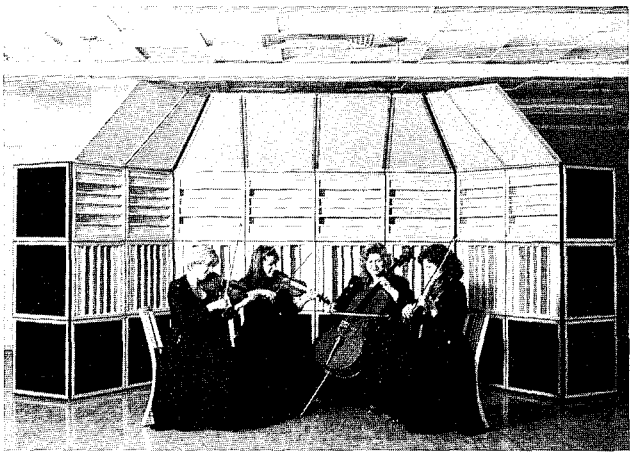


Figure 8. A) Subjective preference evaluation of VAMPS by the Baltimore Symphony Orchestra. B) Photo of the first commercial VAMPS with the Cavani String Quartet.

To accelerate the development of this new acoustic technology, RPG Diffusor Systems, Inc. and Hoffend & Sons, Inc. recently formed a strategic alliance to manufacture, market and distribute worldwide the D'Antonio Performance Signature Series™ - the first acoustically balanced performance shell system offering interchangeable number theoretic sound diffusing, absorbing and reflecting modules in a transportable format. This new line of products utilized the VAMPS concept. Now one shell can satisfy the diverse acoustical requirements of soloists, orchestras, ensembles and choruses.

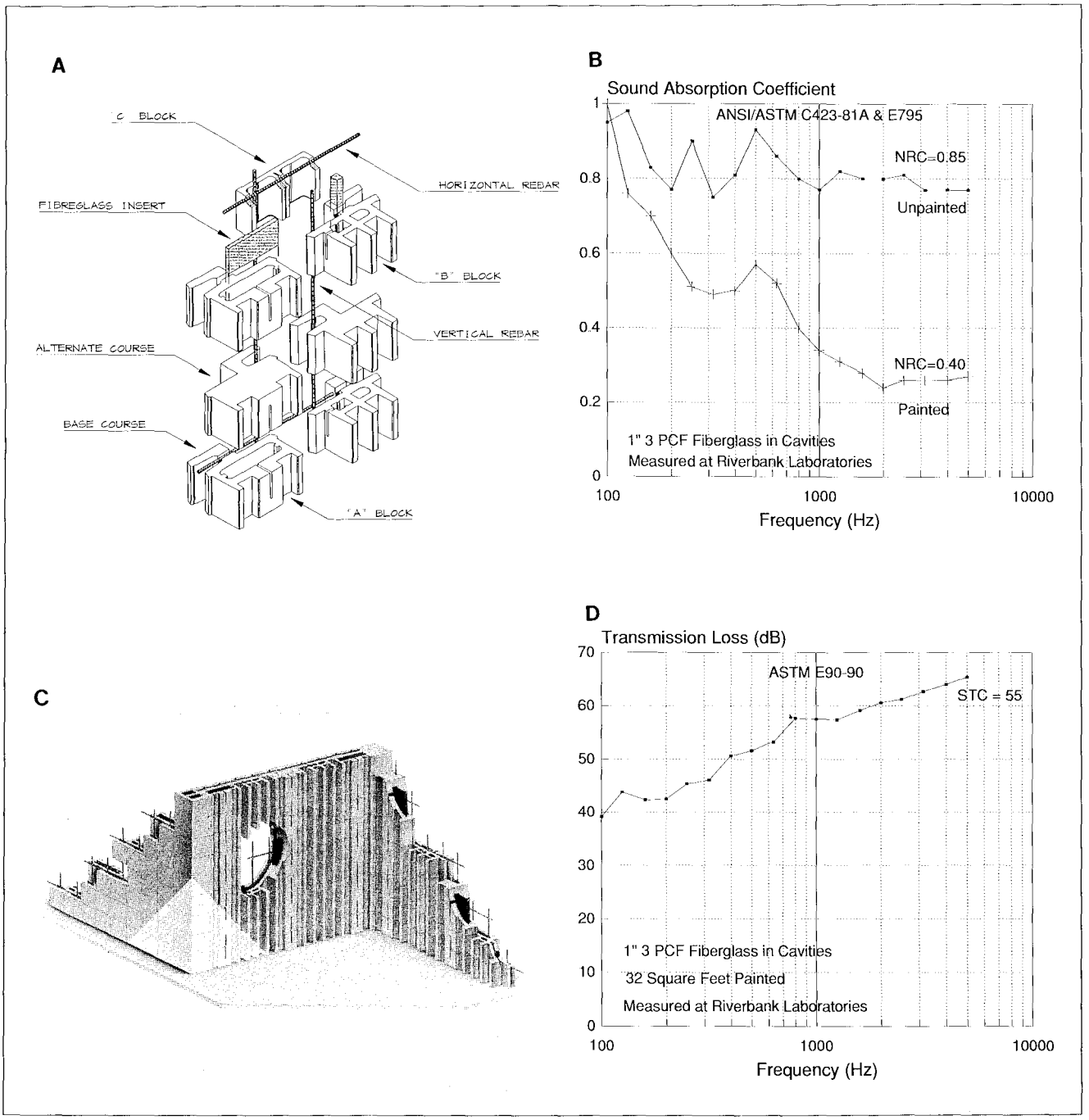


Figure 9. A) Exploded isometric view of DiffusorBlox. B) Random incidence absorption coefficients of unpainted and painted DiffusorBlox per ANSI/ASTM C423-81A & E795. C) DiffusorBlox wall section. D) Sound transmission measurements for DiffusorBlox per ASTM E90-90.

Masonry Units

Prior to the early 19th century either solid brick or block were used for masonry wall construction. The first commercial process to manufacture lightweight hollow concrete building blocks was patented in 1900 by Harmon S. Palmer. In 1917 Francis J. Straub, a Kensington, PA bricklayer with showmanship and imagination, patented CinderBlox - a lightweight, nailable, insulating and sound isolating block made using boiler cinders from the combustion of hard or soft coal. In 1965 the Proudfoot Company patented a unique sound absorbing block called Soundblox® which allowed the concrete masonry unit (CMU) to take on a new role as an acoustical element. The basic resonant sound absorbing principle used in these new blocks first appeared in ancient Greece and Rome in so-called "Vitruv's sound vessels" and later in the medieval churches of Sweden and Denmark. This resonance phenomenon was later investigated by Hermann Ludwig Ferdinand von Helmholtz.

SoundBlox incorporated narrow slots which vented the internal cavities of the hollow block, forming resonant low frequency cavity absorbers. These devices were an important advance but the need for significant absorption below 500 Hz and methods to control the problematic reflections which large wall surfaces created called for a new approach. Attempts were made to form split face blocks and other surface variations but these attempts could only provide limited bandwidth high frequency scattering.

In 1990 almost 100 years after the beginnings of the domestic block industry, Dr. Peter D'Antonio patented DiffusorBlox™ (Patent No. 4,964,486), a new structural acoustic block system based on quadratic residue diffusor technology. DiffusorBlox epitomize the maturation of the structural acoustic CMU, because they provide all of the necessary ingredients for economical acoustical load bearing wall construction, namely - structural integrity, broad-bandwidth sound absorption,

broad-bandwidth wide-angle sound diffusion, fire safety, high transmission loss and aesthetic appearance. The system consists of three distinct blocks A, B and C (Figure 9A) which are keyed for sequenced installation. DiffusorBlox are made locally throughout the United States and Europe by only the highest quality-conscious producers using standard automatic block machine molds for economy, consistency and quality.

DiffusorBlox provide broad-bandwidth wide-angle sound diffusion not offered by any previous CMU device. Sound diffusion is achieved by a unique surface topology which consists of a repetitive grouping of an array of wells of equal width and differing depths separated by vertical dividers. The depths are based on the quadratic residue number theory sequence. The continuous periodic quadratic residue sequence is formed by the adjacent horizontal placement of the keyed A and B blocks (A,B,A,B, . . .) each of which contains a partial sequence. A reflection phase grating (RPG) diffusing wall is easily formed by alternate columns of A and B blocks. Even rows are rotated 180° with respect to odd rows.

DiffusorBlox unique cavity design and large resonator slot depth offer an unprecedented sound absorption coefficient of 1 at 100 Hz which means that 100% of the sound is absorbed at this frequency! The bandwidth of the resonance absorption is broadened by using overlapping and independently tuned resonances. ASTM C423-81A and E795 random incidence absorption results measured at Riverbank Labs using glass fiber panels in the cavity are shown in Figure 9B.

The unique open rear core design of DiffusorBlox permits convenient placement around conduits or plumbing and eliminates time consuming threading of continuous core block over the entire height of existing vertical rebar. Provision for horizontal rebar offers additional structural integrity in seismic areas and the ability to utilize the A block to form vertical pilasters which can be spaced at any interval for structural and load bearing wall heights of over 20 ft. DiffusorBlox satisfy compressive strength structural tests performed at the National Concrete Masonry Association.

Sound transmission tests carried out at Riverbank Laboratories according to ASTM spec E90-90 are shown in Figure 9D. An STC of 55 makes DiffusorBlox very attractive for highway barriers, movie theaters, electrical power plant transformer stations, recording studios and other noise and sound control applications.

*Taken from Kipling:

"They followed all they could follow,
but they couldn't follow my mind,
so I left them sweating and stealing
a year and a half behind."

The word synergy is exemplified by these two men, Greatness is in their countenances, their careers, and their relationship with each other. Dr. Manfred Schroeder was delighted with Dr. D'Antonio's new work applying fractals to diffusion. Give Peter a mathematical hint and an advanced product line appears. His competitors truly have a hard row to hoe, and they indeed are "sweating and stealing a year and a half behind."*

Applications

Effective architectural acoustic designs require an appropriate combination of absorptive, reflective and diffusive surfaces. The specific mix depends on the type of environment desired and whether the objective is: noise control to remove or contain unwanted sounds; or sound control where the goal is to optimize the room acoustics to enhance the perception of music or speech. In noise control applications for offices, computer rooms, machinery rooms, natatoriums, gymnasiums, etc., absorption is the most effective ingredient. In sound control applications for performing arts facilities, auditoriums, lecture halls and worship spaces, diffusion and reflection are of primary importance and absorption plays a minor role. In critical listening spaces such as recording/broadcast studios, A/V presentation rooms, conference/teleconference rooms and listening rooms, absorption, reflection and diffusion are equally important.

The uses of absorption and reflection are fairly straightforward but there is some confusion about diffusion. Diffusive surfaces are equally important in large and small rooms to manipulate both early (<0.10 sec) and late (>0.10 sec) reflections. In sufficiently large rooms with appropriate dimensional ratios, the reflective boundary surfaces are capable of generating a diffuse reverberant sound field. In problematic cases where the reverberant field contains intense isolated specular reflections that corrupt intelligibility and sound quality, diffusors can be used to disperse these reflections without significant absorption. Diffusion also is effective in controlling early reflections in some applications traditionally reserved for absorption especially when there is a desire to simultaneously maintain the natural ambiance of the space.

In large rooms diffusive surfaces can be used: on flat or focusing reflective rear walls and balcony fronts to disperse intense isolated reflections which cause intelligibility loss and confusion; in acoustical shells to provide beneficial early diffuse ensemble reflections for performing musicians enabling them to hear themselves as well as other musicians; on lower side walls to provide diffuse lateral reflections which increase the sense of spaciousness and envelopment for the audience; on low ceilings to reduce the energy of binaurally similar reflections and distribute this energy laterally; as hanging ceiling clouds to introduce early diffuse reflections in high-ceiling rooms; and in combination with specular surfaces to improve sound coverage by uniform spatial distribution of backscattered sound. Thus diffusive surfaces can be used as a corrective measure in renovation or as an integral design ingredient.

In small rooms the temporal distribution of reflected sound is sparse due to the limited number of travel paths which prohibits the formation of a diffuse sound field. Since the walls are relatively close, strong primary reflections which are comparable in intensity to the direct sound dominate the early reflection pattern. As in large rooms, diffusive surfaces are used for nonabsorptive reflection control of primary as well as late reflections to generate a dense diffuse sound field. Much progress has been made in the last 5 years in developing designs for recording and broadcast studios, home concert hall and home theatre rooms incorporating absorptive, reflective and diffusive surfaces which create the psychoacoustical impression of a large space in a physically small room. SV

RPG, QRD Diffusor, Abffusor, Triffusor, Diviewsor, Absorbor, Biffusor, Omniffusor, Terrace, DiffusorBlox, Diffractal, D'Antonio Performance Signature Series, and VAMPS are trademarks of RPG Diffusor Systems.