Subject: Any decernable results from round over at mouth of horns and cabinet edges?
Posted by Norris Wilson on Sat, 23 May 2009 15:40:29 GMT
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Has anyone here done enough experimentation with horns that use a large round over at the mouth edge like Jean-Michel Le Cléac'h
uses to determine it's effect, pro's con's?

If so, what are the differences of a Le Cléac'h horn compared to a design similar to something JBL would use in their studio monitors where the horn mouth sharply terminates and are set against a flat baffle wider than the horn?

Have you added a rounded over extension in the fashion of the Le Cléac'h type to the mouth of a horn such as the Emminence H-290?
If so, what were your conclusions?

Also, has anyone found positive enough effects making it worth implimenting rounding over, or chamfering speaker cabinet edges?

If positive effects were found by rounding over, or chamfering cabinet edges. What size of edge rounded / chamfering was needed to realize these effects, 1/2", 3/4" or larger?

Thanks

NW

Subject: My personal opinions of various design philosophies
Posted by Wayne Parham on Sun, 24 May 2009 03:03:15 GMT
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I have measured and heard the difference from a horn with mouth roundover compared with another similar horn with a sharp terminating edge. I should say right off that this is not always the case, and specifically, if used at a high enough crossover the differences become inaudible. Baffle mounting also helps, and in some cases make an abrupt terminating edge inaudible. That's what I found, in a nutshell.

The differences were only apparent when the horn radiated in freespace, not baffle mounted. I should qualify this to say that the horn with radiused mouth also had a larger mouth to facilitate the rounding. You can see a difference in the low frequency part of the response curve, and also less ripple overall. When baffle mounted, the difference is much less, because the baffle acts sort of as a mouth extension.

About cabinet edge shape, I've done this both ways too. The difference to me is much less obvious, actually, rounded edges are very hard to detect. I would be surprised if they can be detected at all in a double blind test. I can say for sure that unbiased listeners that don't have a

reason to prefer one over the other can't tell the difference. At least, that's been my experience, and I have asked several people to listen to speakers built with and without rounded cabinet edges, similar in all other respects. I did not find anyone that could tell a difference.

I suspect that if I asked someone that believed edge diffraction was audible, I would have had a different result. Naturally, being able to see rounded edges on one speaker and not on another, they would prefer the one with rounded edges. But in a double blind test, I have a strong suspicion they could tell no difference.

In the 1970's, when I was still a youngster building the early models of my speakers, I used to make all cabinet edges rounded. I didn't think edge diffraction was a huge factor, but I did believe it played a part and so it was worth it to me to round the edges. I thought it looked cool too. So to me, it was worth it. A swipe of a router was all it took, so my thought was it made absolutely no sense to build the cabinets any other way.

My cabinetmakers weren't opposed to that when the cabinets were painted, but applying veneers posed a problem. Veneers can be gently wrapped around corners, but it isn't easy. Even if you are careful and are able to bend the veneer without creasing it, edge matching is more difficult. So they always tried to talk me into dropping the rounded-edge feature of my cabinets. I had begun to think of it as part of my "look" - port offset to one side, mirror image stereo pairs, rounded edges. I used all the best parts and made the speakers as perfect as possible in every way. I even objected to their complaints with many of the same arguments I see from the audiophiles that focus on cabinet edge diffraction today.

cabinets with square edges and wanted me to listen to them and compare with ones we had with rounded edges. Back then they had JBL 2205 woofers and different tweeters, but were similar to

different in that they used JBL 2115 woofers. Part of me was irritated, in that I wasn't entirely sure I was even willing to entertain this approach. Like I said, a buzz with a router was all it took to do it "right", in my opinion. But another part of me was at least willing to listen, because it was a big deal to the guys in the shop. And to tell the truth, the square edged cabinets looked great. Perhaps they had done an extra good job on the finish, to help sell me on the idea.

I had to admit, I could not tell the difference at all indoors. Not a bit. Even outdoors, where there are no reflections to overwhelm the subtle influence of cabinet edge diffraction, I could not hear an improvement from the speakers with rounded edges. So we went on to try other people, let them listen and see what they thought. The listeners were all friends and customers, college aged people with youthful good ears and a lack of audiophile bias. These are as close to objective opinions as you can get, in my opinion, because they were all interested in sound quality, and they were all young enough to have good hearing, still capable of hearing sound above 20kHz. These were bohemian types, musicians and artists, both young men and women. In a real way, they were probably more golden-eared than we middle aged audiophiles are now. Unbiased and young.

What were the results? Not a single person could hear an improvement from rounded edge cabinets. Not one. There just was no discernible difference. Not even outdoors, where I would have expected it might have been possible to hear some edge diffraction. You can see it in

measurements as slight little blips in the time domain, sometimes as the tiniest bit of ripple in amplitude response at certain frequencies. But I think it just gets lost in the rest of the clutter of a complex waveform. I am certain that's true indoors, where the influence of reflections from room boundaries, furniture and all the other stuff in the room makes the wave travel even more complex. You just can't hear something as subtle as edge diffraction.

Where I do hear sharp edges is way down in the throat of a horn. I never liked the sound of horns with diffraction slots. I always thought it was because of the sudden discontinuity they cause, and having it in a high-pressure zone makes it worse. You can see ripples in response. Those kinds of horns sound splashy to me. Too strident and artificial. I also don't care for horns with a sharp edge about 1/3rd of the way back from the mouth. Those sound edgy to me too. (Pun intended) Could be that secondary edge didn't matter much, that the splash was all in the throat slot. I don't think I evaluated any horns with an edge near the mouth that didn't also have a Mantaray-style diffraction slot in the throat.

I've used several horns that I've really liked over the years. They've all been smoothly radiused from throat entrance to the asymptote, all had uniform beamwidth 90° horizontal coverage and all were around 40° vertical coverage. My favorite horns have been smoothly curved from throat to mouth but many had a terminating edge where the mouth met the baffle, instead of being radiused to meet the baffle. Those horns don't seem to bother me like the Mantaray types, so maybe the edge at the termination is far enough away from the throat its diffraction isn't audible.

I'd prefer the horn mouth to be radiused when mounted in freespace (not on a baffle). It might be nice on a baffle mounted horn too, but it isn't a deal breaker there. One thing you have to do when radiusing the edge, the mouth has to be made larger to provide space for the curve. That's good because it makes the mouth area larger, which usually makes response smoother. But it's bad because it makes the center-to-center distance greater, which decreases the spread of the vertical nulls. Like most other things in audio, there are trade-offs to consider.

In the end, I have come to some conclusions after three decades of doing this, and some periods of intense study. Everything is subject to change, of course, but I've looked at this pretty long and hard. In my opinion, cabinet edge diffraction has absolutely no audible impact in home hifi installations. There are too many other things in the room that cause reflections and diffraction. Even in the most sterile acoustic environment, like outdoors or heavily treated studios, the effects of cabinet edge diffraction are probably inaudible. Test subjects just do not hear them.

Horn diffraction is audible in devices with sharp edges in the throats. It becomes objectionable only at high SPL, not so much at low listening levels. The further from the throat the edge is, the less impact it has on sound quality. In other words, I would recommend avoiding horns with diffraction slots in the throats, but I would not necessarily be concerned about a horn that meets the baffle with a sharp edge, provided the horn is large enough to work in the passband without ripple. Crossover a little bit high and the mouth edge isn't really an issue. Stay away from horns that are all sharp edges, using instead those that have radiused throat to mouth transitions. Radial horns and waveguides with smooth throats and bodies are great, especially those with 90°x40° to 90°x50° patterns. Naturally, one must employ a crossover that keeps the nulls outside this pattern for best results.

One last thing, if I haven't already bored you with all this. It's not necessarily related to horn or

cabinet edge diffraction, but it's really important to this discussion, nonetheless. I bring it up because I see some of the guys most interested in horn and/or cabinet diffraction being the least concerned about the position of crossover nulls in the listening room. I've always scratched my head at that, because while I think most would agree that extreme diffraction is audible, I would argue that subtle diffraction is not audible. On the other hand, a 10dB notch is something everyone would agree was audible and undesirable, and that's what a crossover null is. It's pretty clear to me which should be the higher priority when balancing trade-offs.

To me, sacrificing sound quality via too-close-spaced vertical nulls (nearly on-axis) is not a reasonable trade-off to get a tiny bit of reduction in high-order (diffraction) modes, something so subtle nobody has even found a way to measure them yet. Just doesn't make sense. Talk about throwing the baby out with the bathwater.

Consider the interaction between the crossover and the spacing between drivers dictated by various horns or waveguides. Look at how those affect the position of vertical nulls. This is a big part of the system design.

About the only difference I see between all of the recent builders of controlled directivity loudspeakers is the shape of the HF horn. All of us are trying to make a speaker with uniform directivity that has 90° horizontal coverage and a useful vertical pattern, as free as possible from anomalies. That's where we differ though.

I don't care if the tweeter is called a waveguide or horn, the goal is the same. What we want is a tweeter with constant horizontal beamwidth matching the woofer at the crossover point, with vertical nulls separated by a useful arc, between which, response is pure.

There are a handful of loudspeaker manufacturers and hobbyists groups that make speakers with this general design philosophy. Most of them fall into one of two groups. There are those that use round or square horns with 90° axisymmetrical CD coverage. Then there are those that use rectangular, oval or elliptical horns with 90° horizontal and approximately 40° vertical coverage. Let's look at each of them, to see what they get from the bargain.

The 90° axisymmetrical (round or square) horn is nice at first glance because it can be made very pure. Polars look great. If this kind of horn were used in isolation, alone in freespace, it would be a no-brainer. It would be the hands-down winner.

Problem is that's not the case. For one thing, it is combined on a baffle with another driver or drivers. The vertical spacing causes a forward lobe to form that is relatively pure, provided the crossover is appropriate for the drivers and their depth from the baffle (respective distances to the listener). Above and below this forward lobe, nulls form which are basically cancellation notches. The response at these angles is terrible, with a huge dip in the crossover region. Outside the null angle, response starts a roller coaster ride of peaks and valleys, depending on the angle and frequency. So basically, there is nothing useful from sound energy outside the null angle.

Another thing we don't want is wide vertical spacing between drivers. The wider the spacing, the closer the vertical nulls. If the vertical spacing between drivers is too wide, then the forward lobe is squished to a thin layer, basically straight in front of the speakers. Too narrow a null angle makes the speakers phasey and unlistenable, because any movement in your chair puts you in a

null.

That's a problem with round horns. They're just too tall and they make the vertical distance between sound sources too great. Closer center-to-center spacing is made possible with rectangular, oval or elliptical horns.

Another problem with 90° round horns is even if you could design a speaker with them that didn't have nulls (you can't), you still would not want the reflections from the floor and ceiling. Most houses have eight foot ceilings, and HF reflections from this surface are unnatural sounding. Probably the most objectionable reflection is ceiling slap. So the last thing you want is tall vertical coverage from a tweeter horn.

Those problems make round horns unworkable to me. Like I said, if they were used in isolation, outdoors, they'd be perfect. No other horn shape would compare. But when combined with other sound sources, the design becomes nonviable, in my opinion because of the narrow angle of the vertical nulls and the level of HF output at large vertical angles.

That brings me to certain kinds of horns and waveguides with asymmetrical patterns having approximately 90°x40° coverage. These have side walls that are shaped exactly the same as the round horns I was just talking about, but the vertical dimension is shorter. The side walls set the horizontal pattern to be constant 90°. The vertical wall angle is made narrower so that HF pattern is not so tall. This also allows closer center-to center spacing with other drivers, because the horn/waveguide is not as tall. The throat transition is smoothly made, matching the driver exit angle to the asymptote flare angle. In that respect, and in horizontal coverage, the asymmetrical horn/waveguide is the same as the axisymmetrical horn/waveguide. It is only the vertical pattern that is different.

The good news about the shorter vertical mouth dimension is it allows closer center-to-center spacing. Its wall angle sets the pattern at the upper range of the passband, making coverage not very tall and limiting ceiling reflections. That's good too. But the bad news is the shorter vertical mouth prevents it from controlling the pattern at the lower end of the passband. The frequency where pattern control is lost is set by the specific features of the horn or waveguide, but most of the ones I've used and/or investigated start to lose pattern control about 3kHz. Some lose it fairly rapidly, others more slowly. But all have collapsing directivity as frequency rises, because that's what it means to lose pattern control at low frequency. The pattern widens down low, which means it collapses up high.

So now let's look at the modern "waveguides" and compare them with older radial horns and other similar designs. Two that I've used pretty extensively are Eminence and Peavey, both provide horns that have uniform 90° horizontal patterns and approximately 40° coverage in the vertical which collapses to this angle around 3kHz. Below that, it's much wider. Some are called radials, some quadratic, some CD. I'm not talking about Mantarays or any of those with sharp edges anywhere - I'm limiting my discussion to those horns that have smooth throat transitions and that also have constant 90° horizontal coverage. These kinds of horns act exactly like modern "waveguides" with similar coverage patterns. They even look a lot the same in cross section, except for a bulge in the corners in some waveguide models.

The reason is pretty simple. The side walls of radial horns, quadratic horns and waveguides are

all very much the same. They're either straight walled with a radiused transition from the throat or they have an oblate spheroidal flare profile, which is very similar. This makes the horizontal pattern constant, and this is the important part of the deal. It also limits diffraction, with the oblate spheroidal models having slightly less diffraction than the straight-walled models. Both are better in terms of diffraction than a horn with a diffraction slot in the throat, both are good.

The shape of the top and bottom flares usually has an oblate spheroidal profile if a waveguide or an exponential curve if a radial horn. This almost doesn't matter though because the mouth height is too small to set the pattern until frequencies well above the crossover overlap band. Whether it's a radial horn, a CD horn or a waveguide, their directivity is constant only in the horizontal. In the vertical, directivity collapses through the crossover region up to 3kHz or so. The vertical nulls actually sort of punctuate the pattern, doing more to notch out the edges of the pattern than the horn, itself. Above 3kHz, the horn/waveguide begins to become more controlled, setting the pattern usually around 40° or 50°, which is plenty of vertical coverage. That's just what we want for home hifi, with our eight foot ceilings.

My point here is there is very little difference between most of the modern 90°x40° or 90°x50° waveguides and some of the older horns, specifically the ones I've described above. The JBL PT waveguides, for example, look like really nice little horns and I think they're better than their older 2370 but I don't think they're better than the Eminence radial horn or the Peavey quadratics. I'd put a rectangular or elliptical oblate spheroidal horn in the same league. These are all pretty similar devices with similar characteristics and similar strengths.

If I were designing a loudspeaker today, I'd probably use one of those kinds of waveguides. However, since I already have designs that use horns that offer the same advantages, I do not see any reason to redesign using them. It isn't an upward path, it's a lateral move. Not that I think the waveguides are worse, by any means, just that I think some of the horns we've used in the past are the same as some of the devices sold now as "waveguides."

I think it is important for people to understand the details. Some radial horns and some quadratic/conical horns with the right feaures are the same thing as 90°x40° waveguides. The things that distinguish these devices are constant horizontal coverage and radiused throat-to-flare transition that minimizes diffraction. Something else they have in common is a limited vertical coverage pattern that collapses above the crossover region. None of them can do much below 3kHz in terms of vertical pattern control because the mouth height is too small. But vertical nulls set the pattern below 3kHz more than the horn/waveguide does anyway.

It's all pretty much the same stuff, and the most important thing is that horns/waveguides with these basic features are used and that the crossover designed to provide smooth response through a nice wide forward lobe. That's what really matters.

Subject: Re: Any decernable results from round over at mouth of horns and cabinet edges?
Posted by Norris Wilson on Sun, 24 May 2009 17:40:33 GMT

Thanks Wayne for taking the time to write out an excellent reply that is very detailed and easy to comprehend. That is very helpful for me due to my limited knowledge on the subject.

I would like to ask you a few more questions if I may.

Regarding the 3kHz collapse of the vertical beam pattern created by the 40 degree angle of the horns that you use in your designs.
I am wondering if the size of the throat of these horns, the H-290 being 1" as a example, have any effects on this 3kHz beam-width collapse point?

Would a compression driver with a 1.4" diameter opening at the throat have this narrowing of the beam-width at a lower frequency, say closer to 2kHz versus 3kHz?

Also, could this 3kHz collapse due to the 40 degree angle of the horn with a 1" throat be manipulated up or downward due to the cut off of the horn? Would the physical size of the mouth of the horn have any effect on this 3kHz narrowing of the beam-width?

As you know, I have the Beyma constant directivity TD-250 1" horns with 90 degree by 40 degree dispersion angles.

There is a bump, or slight rounded over protrusion with a flat side that is positioned on each side of the throat of the horn.
This protrusion is positioned about 1.5" in front of the horn throat where the CD attaches.
Would this protrusion be a diffraction slot that you feel introduces discernible distortion in the bandpass?

BTW, I have heard the negative distortion effects of the sound when using a Manta-ray horn, very peaky and spitty at higher volumes.
But, to be fair, there could be other factors that helped to create these negative effects other than the horn itself in this specific speaker design.

And, changing gears a little here.

Taking the Four Pi design as an example using the JBL 2226 as the woofer, and Emminence H-290 as the horn mounted in the baffle per your latest version.
Could an 8" to 10" diameter midrange driver that is baffle mounted above the treble horn, and crossed in around 250Hz to 300hz from the 2226 with a shallow sloped filter, be retrofited to work properly under your design premise using the vertical nulls? I guess you could say this would be a W-T-M vertically stacked baffle arrangement.

Would there be any type of destructive interferences effecting the proper mating of the midrange and treble horn with this W-T-M stacking arrangement?

And finally, would the midrange driver being placed above the treble horn have any type of sound reproduction anomaly? Anomalies like improper placement of performers, or instruments in the stereo sound field, causing poor imaging?

Thanks for your knowledge.

I would like to thank you for making all of the great changes to the ART forum. The new posting features and thread partioning make life much simpler, especially the edit and spell check features.
My spelling and sentence structure is-m terabull.

NW

Subject: Re: My personal opinions of various design philosophies
Posted by Wayne Parham on Mon, 25 May 2009 04:35:40 GMT
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Norris Wilson wrote on Sun, 24 May 2009 12:40Regarding the 3kHz collapse of the vertical beam pattern created by the 40 degree angle of the horns that you use in your designs. I am wondering if the size of the throat of these horns, the H-290 being 1" as a example, have any effects on this 3kHz beam-width collapse point?
The significance of the ~3kHz point is that's where the 90°x40° horn begins to gain pattern control in the vertical plane. It is related to the mouth size and the flare profile of the top and bottom walls.

The size and angle of the compression driver exit sets the pattern at very high frequencies. The typical 1" exit driver has a "stub" - a short tapered pipe between the phase plug and exit orifice. The taper is 8° to 10°, so from about 14kHz upwards, the pattern narrows to this angle. None of the waveguides are able to retain their beamwidth above this point.

Larger compression drivers shift this narrow beamwidth range down, respective of their exit orifice. A 1.4" device begins to narrow to exit angle at approximately 10kHz and a 2" exit device narrows to exit angle around 7kHz.

Norris Wilson wrote on Sun, 24 May 2009 12:40As you know, I have the Beyma constant directivity TD-250 1" horns with 90 degree by 40 degree dispersion angles.

There is a bump, or slight rounded over protrusion with a flat side that is positioned on each side of the throat of the horn. This protrusion is positioned about 1.5" in front of the horn throat where the CD attaches. Would this protrusion be a diffraction slot that you feel introduces discernible distortion in the bandpass?
This is a diffraction slot, same as the JBL 2370 and many other horns. It can sound spitty, but it does have one advantage: The beamwidth stays high even through the top octave. The edges on each side of the throat provide a diffraction edge that bends the wavefront, keeping the pattern wide even at high frequencies. If it's really important that the top octave have a wide pattern, that kind of horn will do it for you.

One thing the diffraction-free designs can't do is to maintain beamwidth up high. At some point

conicals and radials that don't have a diffraction slot in the throats begin to beam. This is because

the horn isn't setting the pattern anymore, the compression driver is. Without a diffraction slot, the exit angle of the taper in that little stub becomes the significant feature of the waveguide/horn at high frequencies.

You may remember I showed you a version of my wood horn where I had added a diffraction slot to the throat. I did this specifically to experiment with different acoustic devices, to measure and listen and find out what I liked and what I didn't. I didn't like it with sharp edges, but actually found I liked the one I showed you, which had mildly rounded edges. It didn't sound harsh yet provided wide beamwidth all the way up through the top octave.

That horn went through a lot of versions in the prototyping stage. I had in mind a horn with mildly collapsing DI in the vertical and constant directivity in the horizontal, and with a perfectly matched throat to horn transition. I also wanted edge rounding, and a large enough mouth to support freespace operation, since the horn is decorative and would not be baffle mounted. However, the mouth could not be so large that the center-to-center spacing would put vertical nulls too close together, like a round horn does.

I tried one version with straight walls on both sidewalls and the top and bottom, only radiused from the throat transition and at the mouth edge. This is basically the same as the Peavey Quadratic throat horn or the JBL PT waveguides. It was pretty good, but one thing I didn't care for was the region where the horn gained vertical pattern control. It makes a lot of ripple there. I think that's because the horn goes from a very wide pattern to very narrow in the vertical, then after rippling a bit settles down to a fairly constant beamwidth.

The problem is in that transition region, because it creates so much ripple, right around 3kHz. I'd rather have the directivity collapse be more smooth. In a sense, what I'm saying is I don't want constant directivity in the vertical from a horn this size because it cannot be done until midband, so the directivity transition causes problems.

I tried another horn shape with straight sidewalls and an exponential curve on the top and bottom, with a last couple inches closest to the mouth radiused more like a tractrix horn. The sidewalls were radiused from the throat for a smooth transition from driver exit to horn body. Basically, the sidewalls were like a quadratic throat horn or PT waveguide, but the top and bottom walls were exponential, like a radial horn. The mouth exit was radiused like a tractrix.

I liked this one quite a bit, because it provided constant 90° beamwidth in the horizontal plane and smoothly collapsing directivity in the vertical. This one has nice smooth response and good polars. The vertical beamwith was about 50° around 2.5kHz and about 30° at 10kHz. That's a nice usable beamwidth, and its smoothly collapsing DI prevented ripples in the passband.

A third variant has the same curve on the side walls as the cross-section of an oblate spheroid. Top and bottom walls were made same as the previous horn. The mouth exit was radiused, same as the others. This is the shape I ultimately chose.

The differences between the horn with oblate spheroidal side walls and the one with straight side walls were pretty subtle. You could see small response differences, but nothing huge. Each had it's own signature, but both were winners. In the end, I chose the oblate spheroidal profile because I think it makes the most sense. I would have been satisfied with the straight walled

version, but the OS shape was better.

Norris Wilson wrote on Sun, 24 May 2009 12:40Taking the Four Pi design as an example using the JBL 2226 as the woofer, and Eminence H-290 as the horn mounted in the baffle per your latest version. Could an 8" to 10" diameter midrange driver that is baffle mounted above the treble horn, and crossed in around 250Hz to 300hz from the 2226 with a shallow sloped filter, be retrofited to work properly under your design premise using the vertical nulls? I guess you could say this would be a W-T-M vertically stacked baffle arrangement.
I suppose you could do that, but the traditional WMT with a midhorn in the middle does exactly what you want. It provides pattern control via horn directivity and the null angle is set by vertical

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Subject: Re: Any decernable results from round over at mouth of horns and cabinet edges?
Posted by Jeff Robinson on Sat, 27 Jun 2009 16:21:35 GMT
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What's So Sacred about Exponential Horns?

Links to an AES preprint of DB Keele's 1975 article describing the invention of the CD horn. Not directly related to your question, but still interesting.

Jeff Robinson
