Subject: cd horns: conic, os, quadratic...........
Posted by Zeno on Tue, 01 Apr 2008 17:35:40 GMT
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what differences are between pure conic horns, os horns and quadratic throat horns? conical horns have straight walls directly from the throat hole. os and quadratic horns are radiused from throat to match side walls. am i right?

Subject: Constant directivity tweeter horns and waveguides
Posted by Wayne Parham on Wed, 02 Apr 2008 06:11:53 GMT
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Quadratic throat waveguides have conical flares with throats gradually curved to match the entry angle. Oblate spheroidal (OS) waveguides do too. So do prolate spheroidal (PS) waveguides, for that matter. Right now, it seems like more people talk about OS waveguides than do about PS waveguides or quadratic throats. Personally, I find the PS horn to be more useful than OS because OS is axisymmetric but PS can be made to radiate other patterns. In other words, you can have a 90x40 PS horn. It's the same principle though - a conical flare with throat curved to match entry angle. Each of these are nice shapes, in my opinion.
Quadratic Throat Waveguide
Prolate Spheroidal WaveguideThese days, most people talking about the OS shape with regards to waveguides are talking about Geddes waveguides. He has a couple other features that are important to his implementation, one that is easily realized and one that is not. The most important part - which unfortunately is also the one hardest to implement - is making the phase plug match the horn flare. This one isn't done yet, because he hasn't begun to machine throats or phase plugs for compression drivers. That makes the second feature more important to him. He puts open cell foam in the horn to partially absorb sound.

The reason these extra features are important to Geddes is they cut down on what he calls (HOM) high-order modes. Most sound traveling down the horn progresses along its axis. Wavefront propogation is mostly this way, with waves of equal pressure across the horn's cross-section. If the sound source was a perfect radiating sphere of acoustically small dimensions and the throat was conical and acoustically small, I think all wavefront progogation through the horn would be this way. Or if it generated perfect planar waves and the exit was a tube, either way. But real-world horns are not driven by point sources that radiate perfectly spherical wavefronts or planar waves nor are all their features acoustically small. The diaphragm and throat is acoustically small at low frequencies, but becomes large at high frequencies. That's why phase plugs are used, to try and correct this to some degree. Because of these things, some sound can be skewed within the horn, reflecting off the walls rather than propogating along its axis. This is something Geddes has focused his attention on. That's why he adds the foam. The idea is sound traveling along the horn axis will travel through less absorbent foam than sound bouncing off the walls, so the reflected sounds will be absorbed more.

To be honest, I'm not sure how audible HOM are. In fact, I'm not sure they've been measured yet, although it does stand to reason that they exist. Geddes claims night and day difference between a horn treated with foam to reduce HOM and one without, but I didn't hear any qualitative difference. I do like the horn shape, mostly for its absense of discontinuities from abrupt flare changes and for its constant directivity. I could do without the foam.

When you bolt a 1" compression driver onto a quadratic, oblate spheroidal, prolate spheroidal or pure conical flare, you get reasonably constant directivity within a band determined by the dimensions of the waveguide. At some low frequency point, it will lose pattern control. At high frequency, the 1" entrance becomes acoustically large, so the features within the compression driver are shaping wavefront propogation, not the waveguide. The waveguide has basically no influence at high frequencies if the throat is a gradually expanding shape. So the pattern narrows drastically in the top octave, since the exit flare angle of most 1" compression drivers is 5° to 10°. This abrupt beaming boosts on-axis sound in the top octave (right where some drivers exhibit breakup peaks) and may be more reason to put absorbent foam in a waveguide like this than anything else.

Subject: Re: Constant directivity tweeter horns and waveguides
Posted by Zeno on Wed, 02 Apr 2008 16:38:50 GMT
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thanks for detailed reply!!

Subject: Re: Constant directivity tweeter horns and waveguides
Posted by Randy on Wed, 02 Apr 2008 18:46:42 GMT
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"If the sound source was a perfect radiating sphere of acoustically small dimensions and the throat was conical and acoustically small, I think all wavefront progogation through the horn would be this way. Or if it generated perfect planar waves and the exit was a tube, either way."Compression drivers use of the phase plug is to make wavefronts diverge to approximate a planar wave AFAIK. However, cones and domes make omnidirectional spherical waves.From this I would think a pure conical horn would be the best way to load a dome or cone driver. Your thoughts?Randy

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Subject: Re: Constant directivity tweeter horns and waveguides
Posted by Wayne Parham on Wed, 02 Apr 2008 22:43:27 GMT
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At frequencies where the radiator is acoustically small, the wavefront is basically an omnidirectional sphere. If on a baffle, it becomes a hemisphere in the range of frequencies where the radiator is acoustically small but the baffle is acoustically large. As frequencies goes up, so that the radiator becomes acoustically large, the beamwidth will narrow.A conical horn is like a baffle that narrows directivity smaller than 180°. Wavefront is basically spherical, bounded by the wall angle. Like the baffle mounted condition, this holds true through the range of frequencies where the throat is acoustically small and the mouth is acoustically large. Above and below this range, the pattern is no longer set by wall angle.

Subject: Re: Constant directivity tweeter horns and waveguides
Posted by Martin on Thu, 03 Apr 2008 12:27:26 GMT
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Wayne,That is a really interesting post. I am going to save that one and will put a lot of thought into what you wrote. Excellent!Martin

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Subject: Re: Constant directivity tweeter horns and waveguides
Posted by Zeno on Thu, 03 Apr 2008 16:29:37 GMT
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what about h290 horns? they have a round throat like spheroid and quadratic horns.many thanks for kind attention and good bless you.

Subject: Re: Constant directivity tweeter horns and waveguides
Posted by Wayne Parham on Thu, 03 Apr 2008 17:42:50 GMT
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You're right, the H290 transitions smoothly from the throat expanding to the mouth without a diffraction slot. I like this horn, but it does beam in the top octave. No way around it in a horn like this without a diffraction slot.

Remember that we're only talking about the top octave here. Below 10kHz, the horn sets the radiation pattern. But above that, the exit features of a 1" compression driver set the pattern. That's why the pattern narrows, and why on-axis SPL increases. It does so at the expense of off-axis energy, which falls off.

Earlier I said, "this abrupt beaming boosts on-axis sound in the top octave", which is true for all horns and waveguides that don't have a diffraction slot. It's usually so high in frequency that nobody really notices, it just gives a bit more "air." But it is definitely a measureable increase above 10kHz on-axis, and you can also see the absense off-axis. For that reason, most speakers having constant directivity without a diffraction slot in the tweeter sound better to me 10-20° off-axis than they do straight on.

If you're familiar with my crossover, there is an optional component C1a. A small value capacitor there can be used to decrease output in the top octave. Capacitor C1 bypasses the padding to increase HF output, but if you're using a compression driver/horn combo that becomes too strident in the top octave, you can install C1a.

Subject: Re: Constant directivity tweeter horns and waveguides
Posted by Wayne Parham on Thu, 03 Apr 2008 18:06:55 GMT
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Kind words, Martin, thanks. Means a lot coming from you.My thoughts are just one man's opinion. I'm always learning and making incremental improvements as I do.I'm really interested in your thoughts. At low frequency, a horn can easily (and accurately, I think) be modeled with simple 1P formulas. But at higher frequency, where the diaphragm doesn't move as a piston, where horn features become acoustically large, etc, that's where an empirical approach has always been required. Any ideas on some of those thorny issues? I'm not sure we can make a closed form solution for them, seems like they can't be solved without complex modeing techniques. I guess that really takes us back to the FEA / BEM thread, but these topics are sort of related.

Subject: Re: Constant directivity tweeter horns and waveguides
Posted by Martin on Thu, 03 Apr 2008 18:57:57 GMT
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Wayne,You are way ahead of me when it comes to understanding and designing horns. But I am working on a couple of horn related modeling efforts. I'll list them below in no particular order.1) I want to change my 1D modeling tool to get away from flat plane wave assumptions. I intend to model the waves in the horn curved such that they are normal to the side walls. This will mean more reflections when the geometry changes. I am not sure how significant this will be.2) Modeling what goes on at the mouth is always interesting. If you follow a textbook derivation that is based on Webster's equation, then the mouth acoustic impedance is assumed to be modeled as a piston in an infinite baffle. In other words the volume velocity and pressure are constant everywhere on the surface that is defiend as the mouth. In the past week or so I have calculated the pressure profile, assuming a constant velocity, on the surface of the mouth. So I now have a position dependent acoustic impedance of the mouth. I think this will eventually lead me to velocities at the mouth in multiple directions, axial and across the horn's mouth (out of plane motions).3) As part of 2), I have also started to include the edge diffraction effects of a baffle or just the edge of the mouth itself when calculating the mouth's acosutic impedance. I got this working last night and will continue to explore this over the weekend. I can also see this becoming more sophisticated as I look at a diffraction due to a discontinuity as the mouth transitions into the room and the wave shape "distorts" from a smooth curved profile. (Man, that sounds like a snake oil saleman's techno-babble.) 4) I also want to add some plots to my documentation to show the sound waves in the mouth as a function of frequency, above and below the cut-off frequencies for a few different horn profiles solved with Webster's equation modeling.5) I think numerical solutions are the key, I am not smart enough to do a closed form solution. I will probably start with brute force approaches that calculate forever and then start to simplify and take shortcuts.6) I also think there will be a lot of value in experimenting and measuring some of the compression driver horns. So I am putting togther a list of compression drivers and horn profiles I want to buy, model, and test (w/ Praxis) to help calibrate myself. I will also be very interested to substitute these into my home system to assess the pro's and con's of them compared to my direct radiator drivers.I guess I am keeping busy and horns have the bulk of my attention right now, but I have said that before and it has been short lived.Keeping busy,Martin

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Subject: Re: Constant directivity tweeter horns and waveguides
Posted by Zeno on Thu, 03 Apr 2008 19:47:12 GMT
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as always thank you kindly for the detailed and informational reply!!

Subject: Re: Constant directivity tweeter horns and waveguides
Posted by Wayne Parham on Thu, 03 Apr 2008 22:53:17 GMT
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I've always been more comfortable with iterative approaches too, probably a result of my computer background.As you approach new ideas for modeling features, please feel free to kick it around here. Sometimes it's easier to roll your sleeves up and dig in on your own, but sometimes it helps to toss ideas around. It would be great to have improved models that included some of the unusual 3D acoustic features that are impossible to describe with a 1D model.Whatever paths you take, I'm confident you'll be as thorough as usual. I'm very interested in what you come up with.

Subject: Re: Constant directivity tweeter horns and waveguides
Posted by Norris Wilson on Fri, 04 Apr 2008 00:21:03 GMT
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Excellent information, thanks for your time in bringing it to us.I am looking forward to any more information that you might add.I would love to hear you make a presentation at LSAF along these same lines about horn design. Norris

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Subject: Re: Constant directivity tweeter horns and waveguides
Posted by Wayne Parham on Fri, 04 Apr 2008 03:57:20 GMT
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Thanks Norris, kind of you to say.

This year, I'm not giving a talk at LSAF 'cause I'll have my hands full. I'm even needing help, looking for a volunteer to take photos in each room and list the components so we can put them on the LSAF website. With 'lil Eddie running around, at his tender age of 19 months, we'll be doing good just to man the room. Melissa will likely take him swimming and out doing fun stuff like that, and that leaves me to hang out in the room.

Anyway, I'm not the guy to do a talk on horns. I understand them pretty well I think, and have even made a contribution or two. But most of my contributions have been indirect, like the cooling plug. Mostly, I'm an implementer of what I understand to be the best technologies I can find. I'm an engineer, not a scientist. I'm comfortable giving a talk on Ohms law and reactive circuits as applied to crossovers, but that's it. And this year we have Keith Larson giving a presentation on the Smith and Larson measurement system, so that will likely cover many of the same bases, and a few more.

Subject: Re: Constant directivity tweeter horns and waveguides
Posted by Randy on Mon, 07 Apr 2008 20:30:15 GMT
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I've read on other forums that diffraction is what causes "horn honk" or the "cupped hands" horn coloration. I'm not sure because I've heard it on many horns of different types. All thoughts appreciated.Randy

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Subject: Re: Constant directivity tweeter horns and waveguides
Posted by Wayne Parham on Mon, 07 Apr 2008 22:51:50 GMT
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I think the thing most often perceived as "horn honk" is uneven amplitude response, particularly an exagerated midrange. It is usually when there is a midrange resonance that boosts a narrow region and then falls off at higher frequency. The horns that are usually considered to be colored are the ones that have some kind of midrange peak that isn't equalized. Said another way, if a horn is made such that there is a peak in sound output that isn't equalized, then that will definitely sound "honky", especially if it's in the midrange, where our ears are most sensitive.When there's an abrupt change in flare rate in a horn, the discontinuity causes an acoustic reflection back towards the throat. This can be seen as an impedance spike at a frequency depending on the position in the horn. The mouth termination is one source of discontinuity, and it results in an impedance peak at the lower frequency end of the scale. If there are other transitions, they can be seen at higher frequencies.The backwave reflection causes a resonant condition that results in an impedance increase, and usually an increase in sound output as well. The reflected wave combines with the source wave and produces pipe mode resonances. The frequency, shape and size of the resonances depends on the distance between source and termination, and also on other factors such as resistance and bandwidth, damping and Q.Most compression tweeter horns have mouth terminations that cause this condition to exist somewhere between 500Hz and 2kHz, depending on the size of the horn. Sometimes a horn isn't well-behaved at the lower end of its range and if it is used too low, it generates a pretty big peak. One should use caution to ensure the crossover point chosen is high enough to avoid this.Another thing to consider is the power response of the compression driver itself. They're very efficient for a couple of octaves, three at most. Above that, they begin to rolloff. At 2kHz, efficiency of a good 1" compression horn is 40% or so but by 10kHz it is only around 5%. So for example, a 1" compression driver is usually pretty strong from about 1kHz to 4kHz but then response falls 6dB/octave because of diaphragm mass. Output is generally 12dB down in the top octave.If a horn provides constant directivity, then it will need electrical equalization to compensate for falling power response. Some horns begin to beam at higher frequencies which provides on axis EQ, but off axis falls off very rapidly at high frequencies. Such a horn may sound good directly on axis in an anechoic environment, but most people don't listen in anechoic conditions. Indoors, the reverberent field tracks the power response. So without EQ, the total sound energy in the room is much louder below 4kHz. This condition may contribute to what some identify as horn coloration.As for diffraction, my experience is that it isn't high on the list of audio annoyances. The one exception is where arrays are used, diffraction slots in the throats of CD horns cause the apparent apex to be different along the horizontal axis than the vertical. I am not at all sure that diffraction is a qualitative problem that adversely affects performance in any other way.A long time ago, I used to round all the edges of my loudspeakers to prevent edge diffraction. My thinking was it was easy enough to do, so even if the benefits were marginal it was worth doing. But it was only easy to do on painted cabinets. Bending veneers around the corners gave my cabinet makers fits, because sometimes the veener would break as it was applied. So we built cabinets both ways, with rounded edges and without and listened for differences. I listened, the guys building them listened, and we had others listen too. Not a single person could hear a difference. This makes me tend to believe that to focus on edge diffraction as a potential problem might be exaggerated.