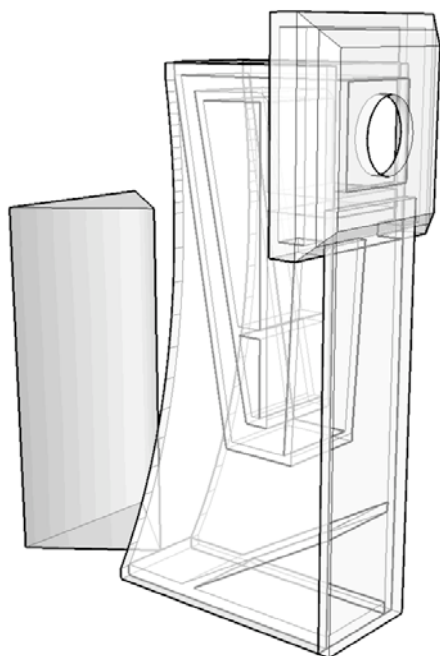


The Frugel-Horn – Open Source Corner Horn Project

Version 1.0.3 Plan Set

(updated 13-march-07)



Drawings/Contents

Sheet i0/ Overview
Sheet i1/ Build Levels

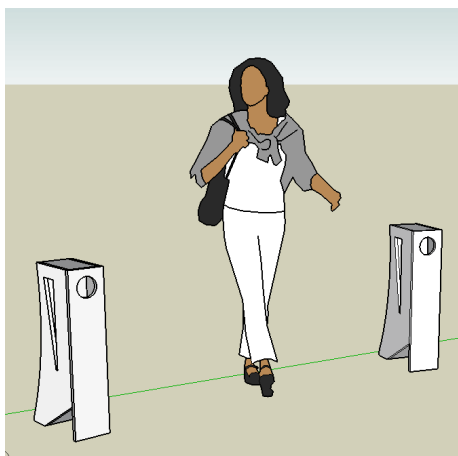
Sheet FH0/ Horn Path & Notes
Sheet FH1/ Parts placement detail
Sheet FH2 Internal parts detail
Sheet FH3/ Deflector
Sheet FH4/ Side pattern (imperial)
Sheet FH5/ Side pattern (metric)
Sheet FH6/ Compression Chamber

Sheet Ao-W0/ Wedgie Details
Sheet Ao-W1/ Wedgie Plan
Sheet Ao-W2/ Wedgie Placement
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Sheet Ao-W4/ Side pattern (imperial)
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Sheet A1-S0/ SupraBaffle
Sheet A1-S1/ SupraBaffle Shapes

Sheet A2-B0/Modified Buschhorn

please email me <dave@planet10-hifi.com> with corrections & suggestions to make this document more useful



The Frugel-Horn (cross between flugel horn & frugal) is an open-source DIY project to develop a small, inexpensive corner horn. It is not a commercial product*. We started with a modified-Buschhorn, then made changes to make the design more rational & more versatile for the DIY community. With the involvement of the entire community sonics can rival & exceed any speaker in its niche.

Your Feedback helps improve this design and spurs continued development.

The web site:

<<http://www.frugal-horn.com/Frugel-Horn.html>>

Design History

α 1.0.0 / A modified Buschhorn 1 -- enlarged to accomodate the larger drivers used in this design.

α 1.2.1 / Refolding of 1.0.0. This was our 1st Frugel-Horn build.

α 1.3.0 = version 1.0 Level 0 / Simplifications & minor change of some details to ease building (drawings for this were in limited release)

α 1.4.0 = version 1.0 / Increases cabinet width, adds a curved rear mouth, and deflector to improve bass extension by 10-12 Hz and reduce reflections off the "supporting" corner back into the horn mouth thus reducing the ripple in the LF response.

Compression Chamber Size

The design accomodates a large range of compression chamber sizes to (hopefully) help allow a wide range of drivers. The internal partitions naturally define 3 possibilities -- small, medium, & large. These can be further refined by adding fill-in material. The smaller the CC size the higher the acoustic low-pass filter to the rear-loaded horn. For the initially targeted FE126e & FE108eΣ, the small CC is a good starting point.

Drivers with similar parameters to the 2 target drivers are likely to work best, but like every other horn i have seen, people will want to try many drivers, and the variable CC is there to aid in that endeavor.

supraBaffle

The purpose of the supraBaffle is to push roll-off due to baffle step down to the point where the horn action takes over flattening the speaker's frequency response. The smaller the compression chamber the smaller the supraBaffle required. Since the supraBaffle is applicable to any skinny speaker another document covering it in more detail is in the works.

Build Levels

The Frugel-Horn can be built to a number of levels. Although a full-on Level 3 is best, even at Level 0 the horn is good. With each additional level the sonics are improved but the build moves away from a rectangular box which may or may not be a WAF issue (my wife prefers the Level 3 looks :^)

Voids

Unused voids in a folded horn are quite common. The voids in the Frugel-Horn can be left as is, filled (sand, lead shot, kitty litter....) or as illustrated in many of the renderings and examples, opened up so that they are no longer void. This also adds an aesthetic touch and gives a visual indication that this is indeed a horn.

Adding your own creative touch

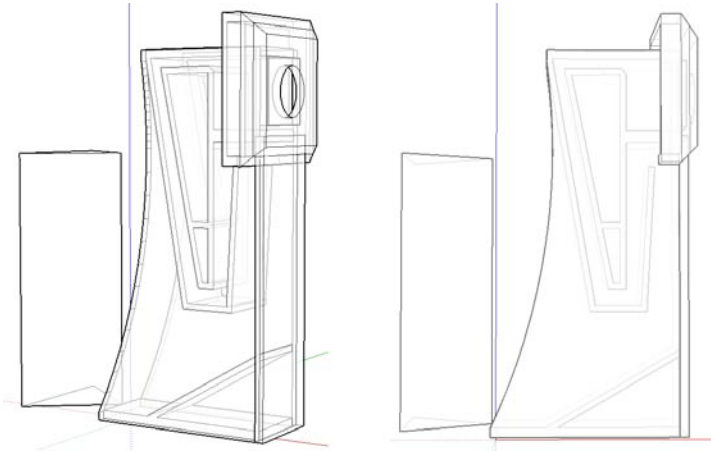
The Frugel-Horn design intentionally leaves a lot of scope for your own creative aesthetic. Even on the few builds to-date there are examples of a wide range of artistic interpretation.

The Frugel-Horn
 Open Source Corner Horn
 Project V1.0 sheet 11

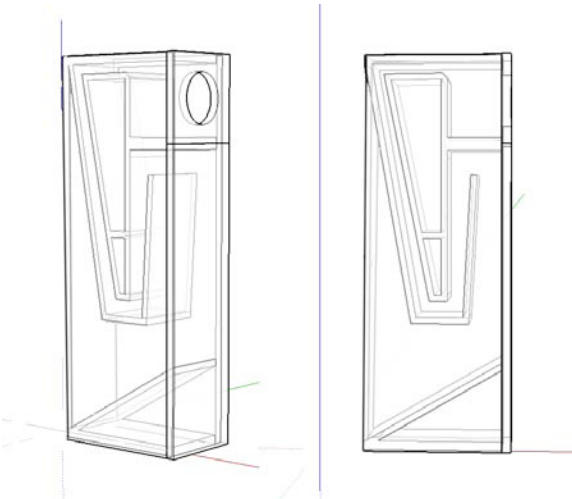
Build Levels

drawn by dld
 09-october-2006

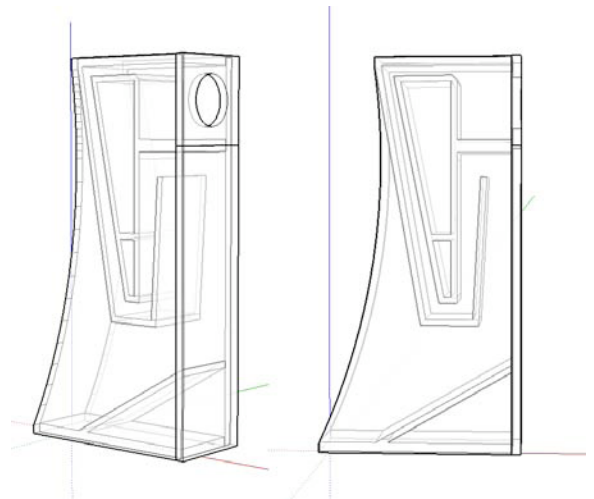
Level 0 to Level 1 upgrade once built is a bit tricky, but upgrades from other levels to higher levels can be accomplished step-by-step just by adding to the current build.



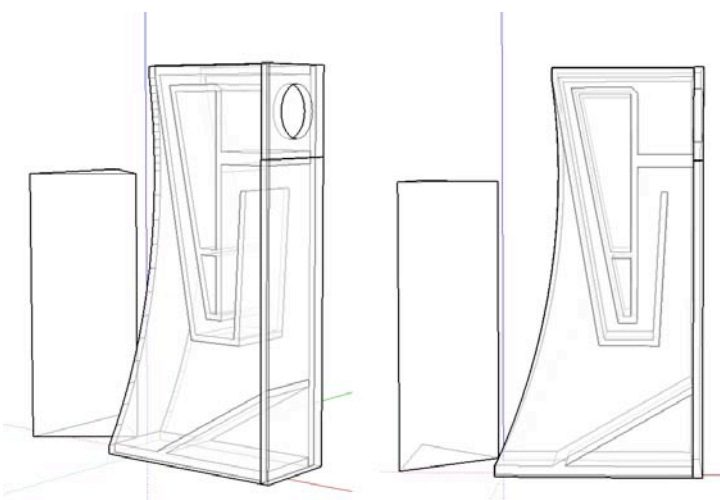
Level 3 / Full Build. Horn with supraBaffle & deflector



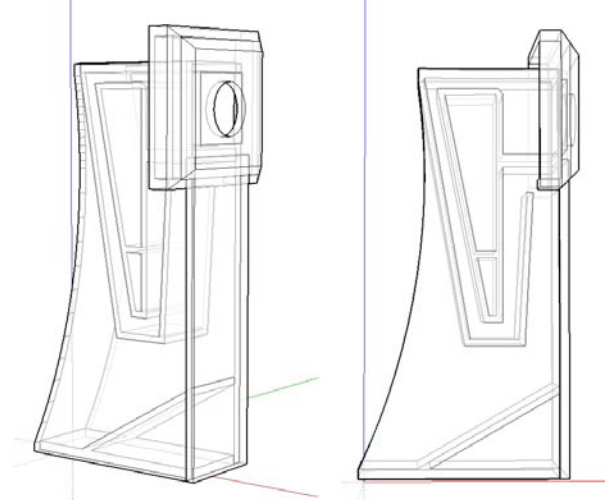
Level 0 / The horn in a rectangular box. Instead of the curved rear the sides are made straight down from the back of the top panel.



Level 1 / Just the horn but with curved mouth



Level 2a / Add the deflector to Level 1



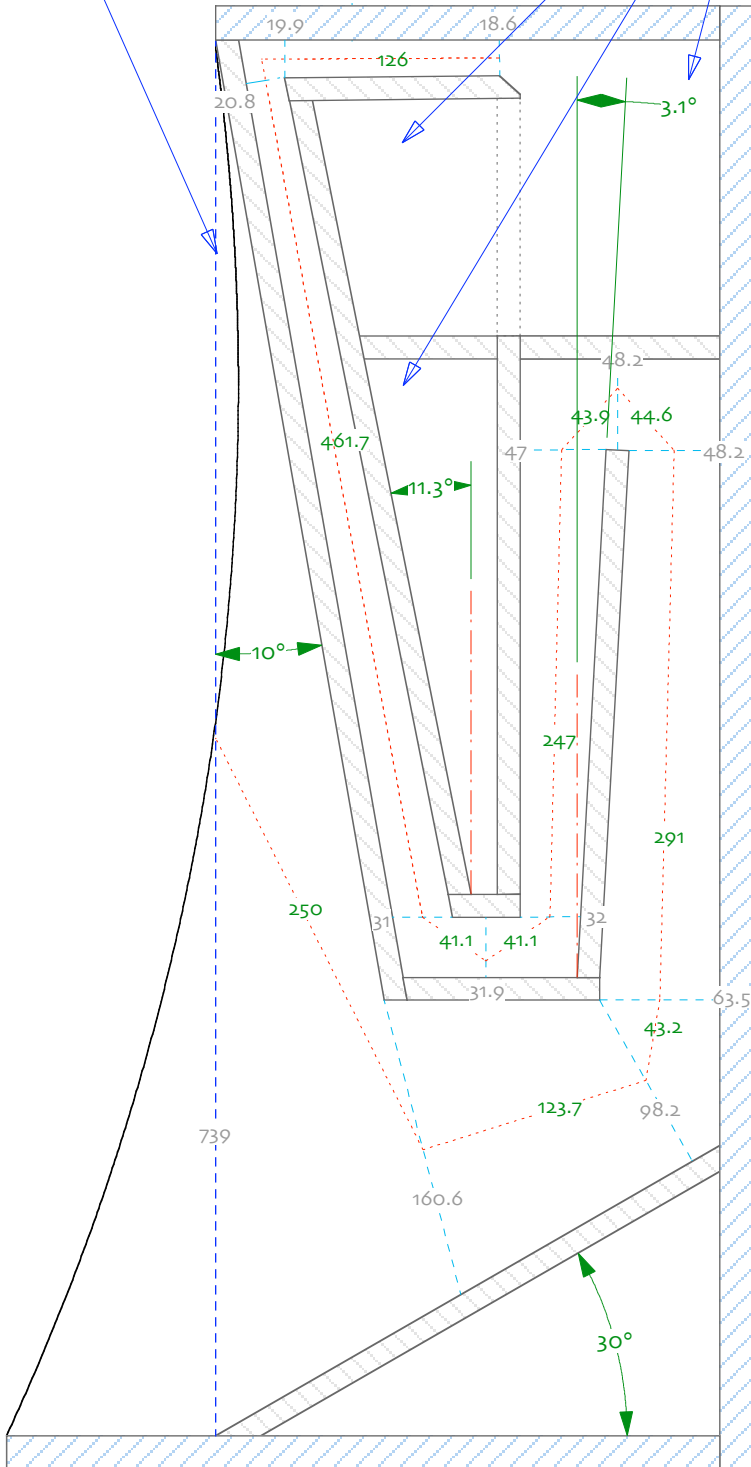
Level 2b / Add a supraBaffle to Level 1

The Frugel-Horn
 Open Source Corner Horn
 Project V1.0 sheet FHO
 Horn Path & Notes

drawn by dld
 updated 05-october-2006

These partitions can be removed, changed, modified to accommodate different size compression chambers to allow some driver versatility. See Sheet 7 (page 8)

Cut side walls at this line for a Level 0 build



1/ This alpha is (mostly) consistent with the HornShope expansion.

2/ Internal width is 140mm, internal partitions drawn are 12mm, front, top, bottom, sides are 18mm (feel free to use larger or smaller material for the outer panels)

3/ optional ~300 mm wide/diameter supra-baffle not shown. Its purpose is to move the baffle-step drop off to where the horn action starts flattening lower midrange FR

4/ Has up to 5.4 litre compression chamber using all of the upper void -- this should give some latitude for other drivers. The design has partitions which lend themselves to small, medium & large CCs. Choose one larger than needed and add "fill" to decrease it as required

5/ intended for Fostex FE126 or FE108eΣ, horn action from ~ 50-200 (250) Hz

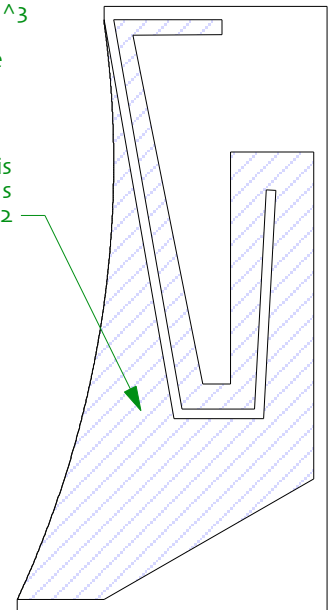
6/ Deflector and curved mouth are optional, but recommended. In conjunction they increase mouth size and give 10-12 Hz more extension in the bottom.

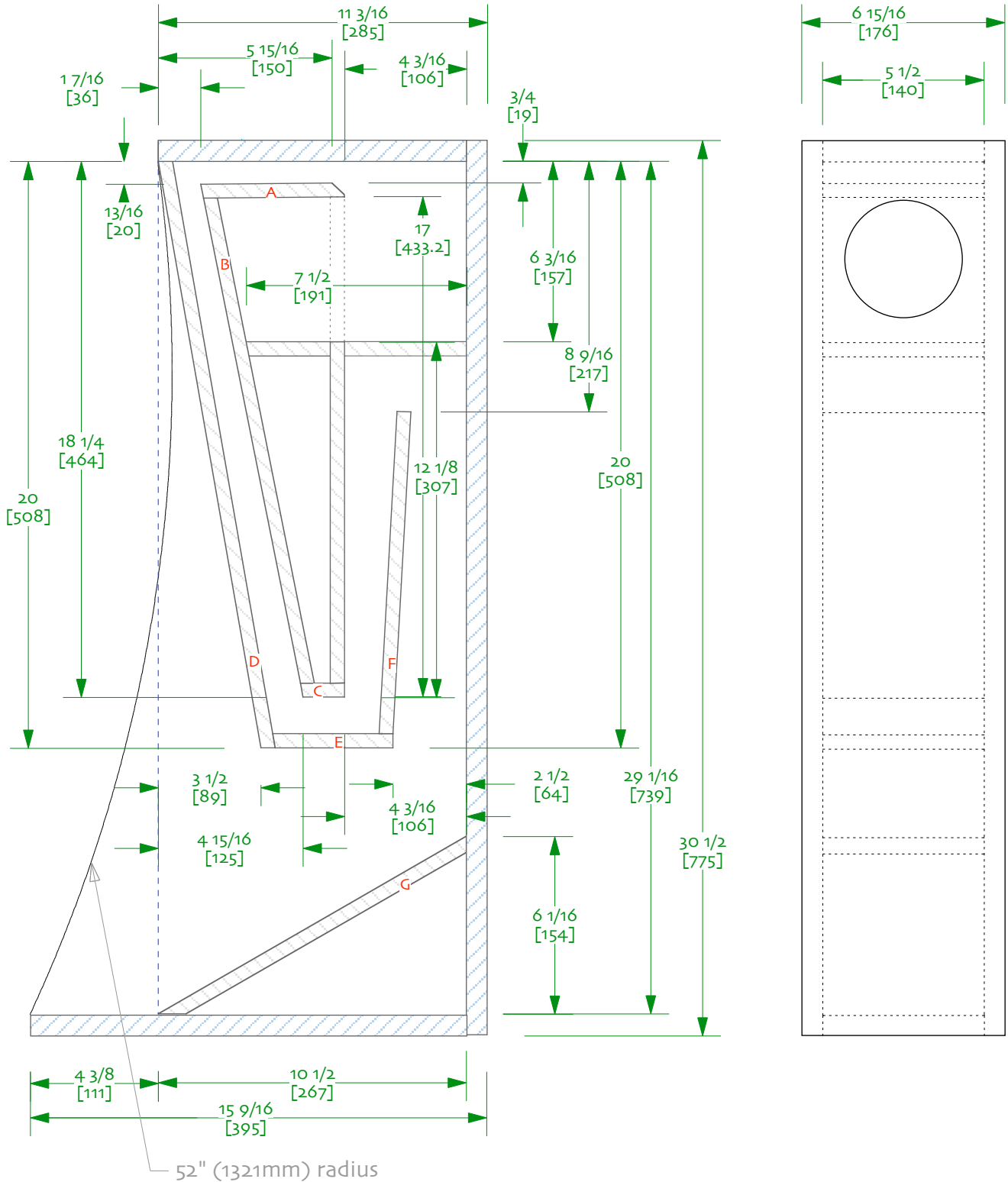
1262.1 cm² x 14 cm width

= 17669 cm³

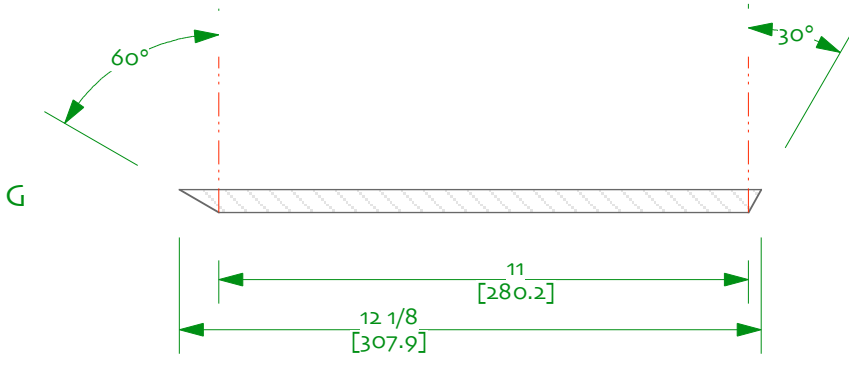
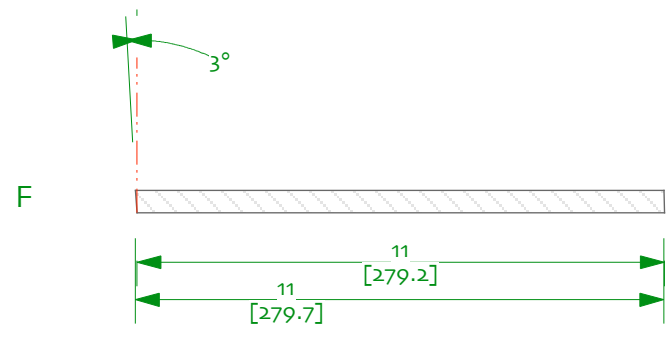
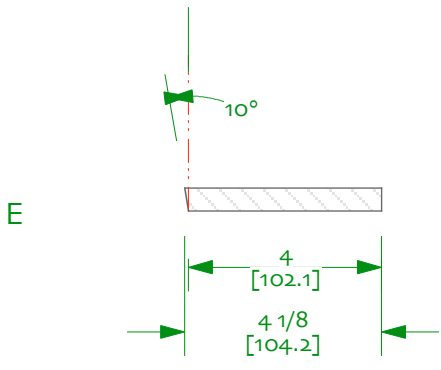
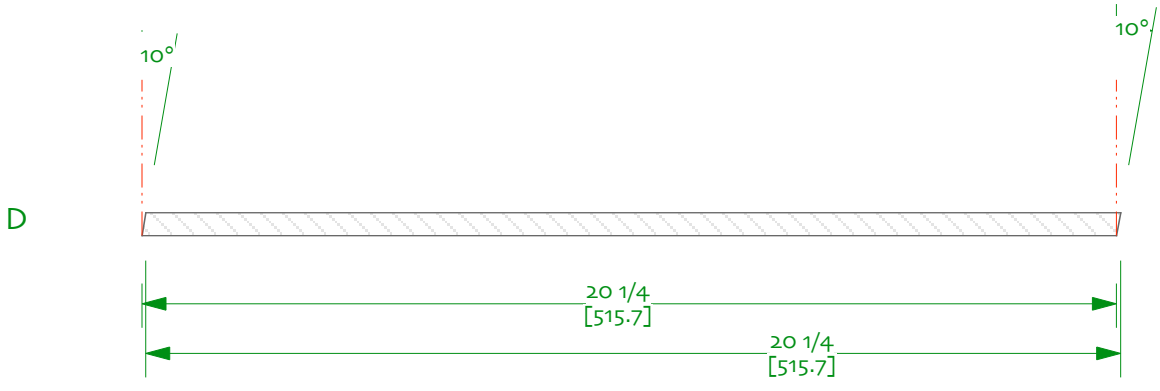
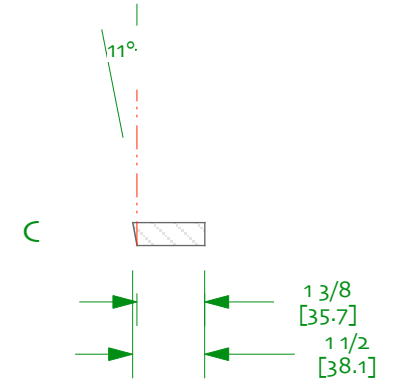
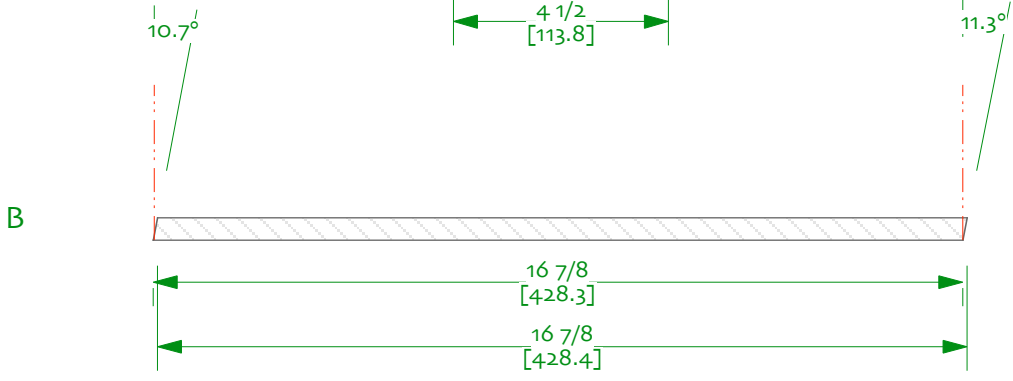
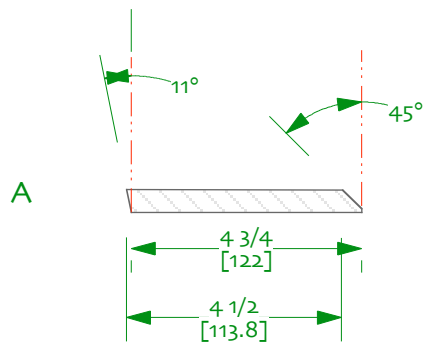
= 17.67 litre

Area of this shape is 1262.1 cm²

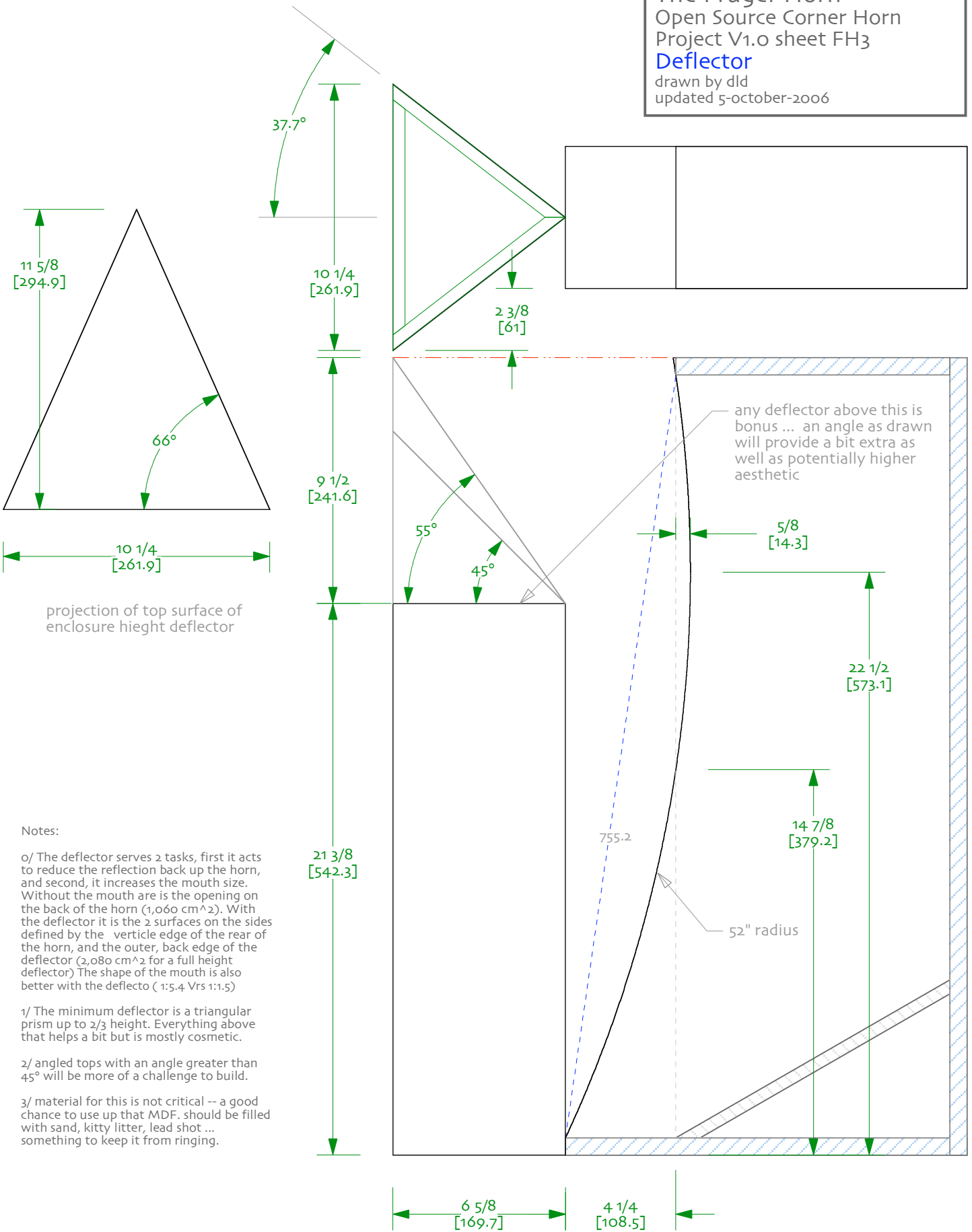




The Frugal-Horn
 Open Source Corner Horn
 Project V1.0 sheet FH2
Internal Panel Details
 drawn by dld
 17-june-2006



The Frugel-Horn
 Open Source Corner Horn
 Project V1.0 sheet FH3
Deflector
 drawn by dld
 updated 5-october-2006



projection of top surface of enclosure height deflector

Notes:

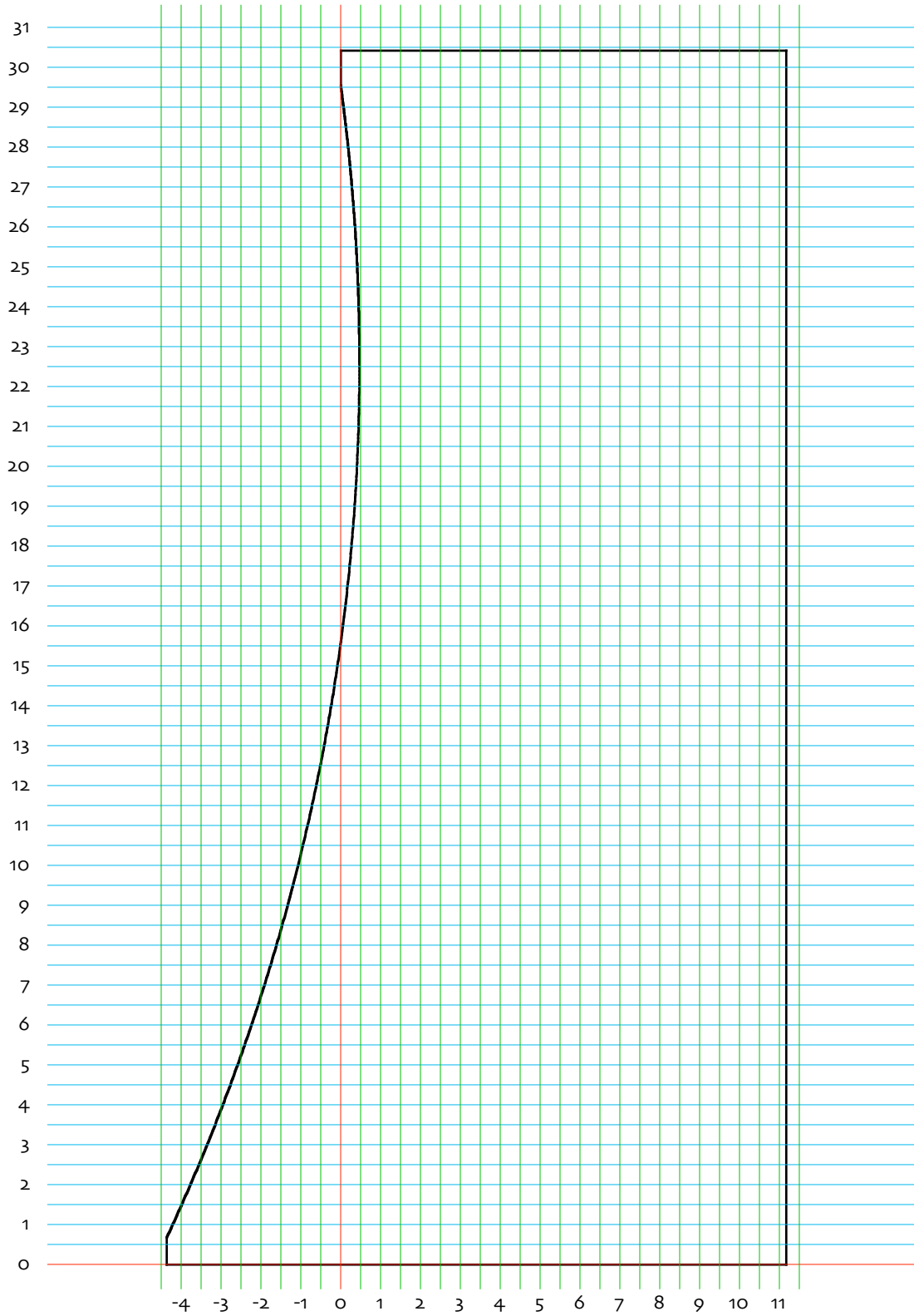
0/ The deflector serves 2 tasks, first it acts to reduce the reflection back up the horn, and second, it increases the mouth size. Without the mouth are is the opening on the back of the horn (1,060 cm²). With the deflector it is the 2 surfaces on the sides defined by the verticle edge of the rear of the horn, and the outer, back edge of the deflector (2,080 cm² for a full height deflector) The shape of the mouth is also better with the deflecto (1:5.4 Vrs 1:1.5)

1/ The minimum deflector is a triangular prism up to 2/3 height. Everything above that helps a bit but is mostly cosmetic.

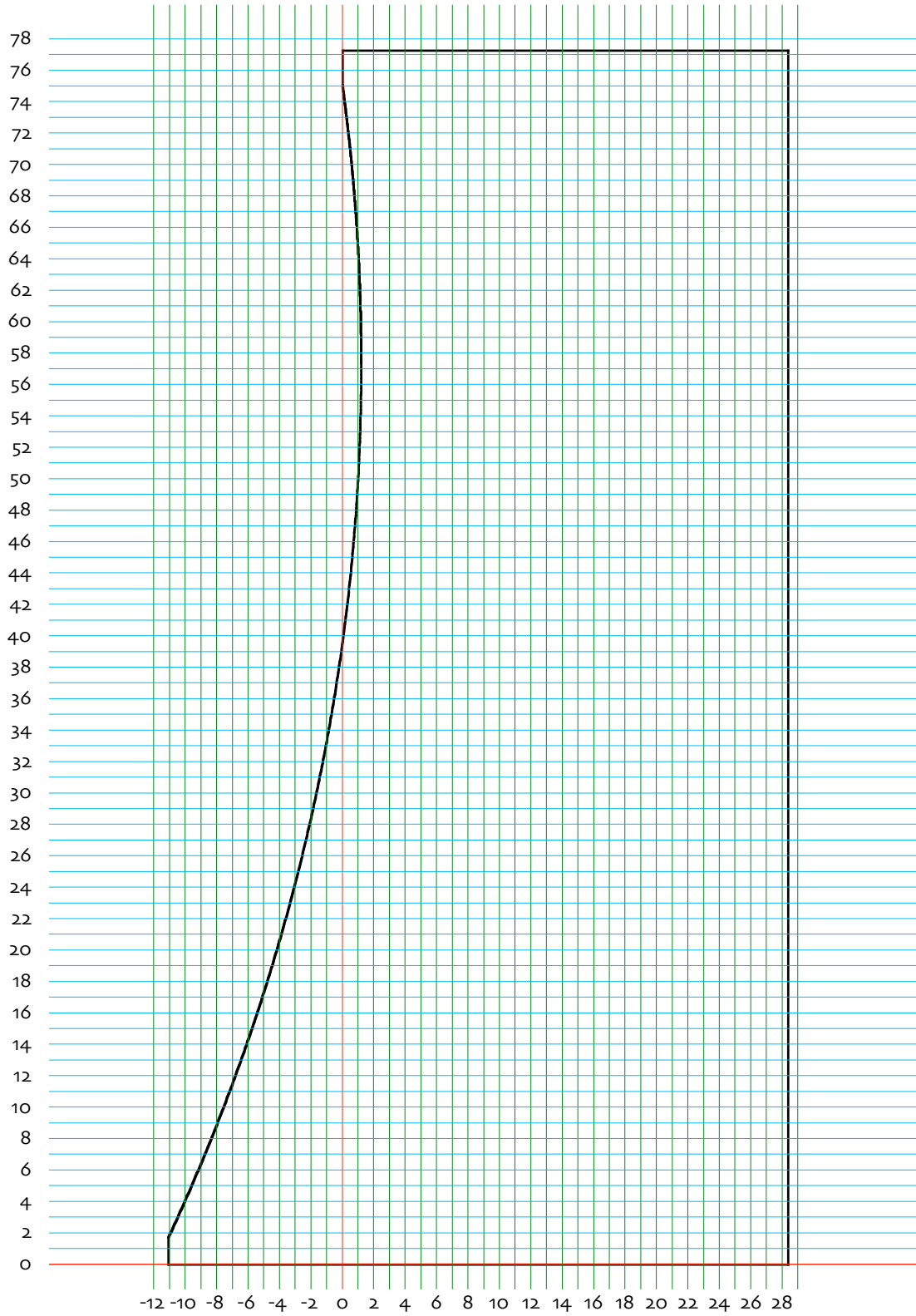
2/ angled tops with an angle greater than 45° will be more of a challenge to build.








3/ material for this is not critical -- a good chance to use up that MDF. should be filled with sand, kitty litter, lead shot ... something to keep it from ringing.

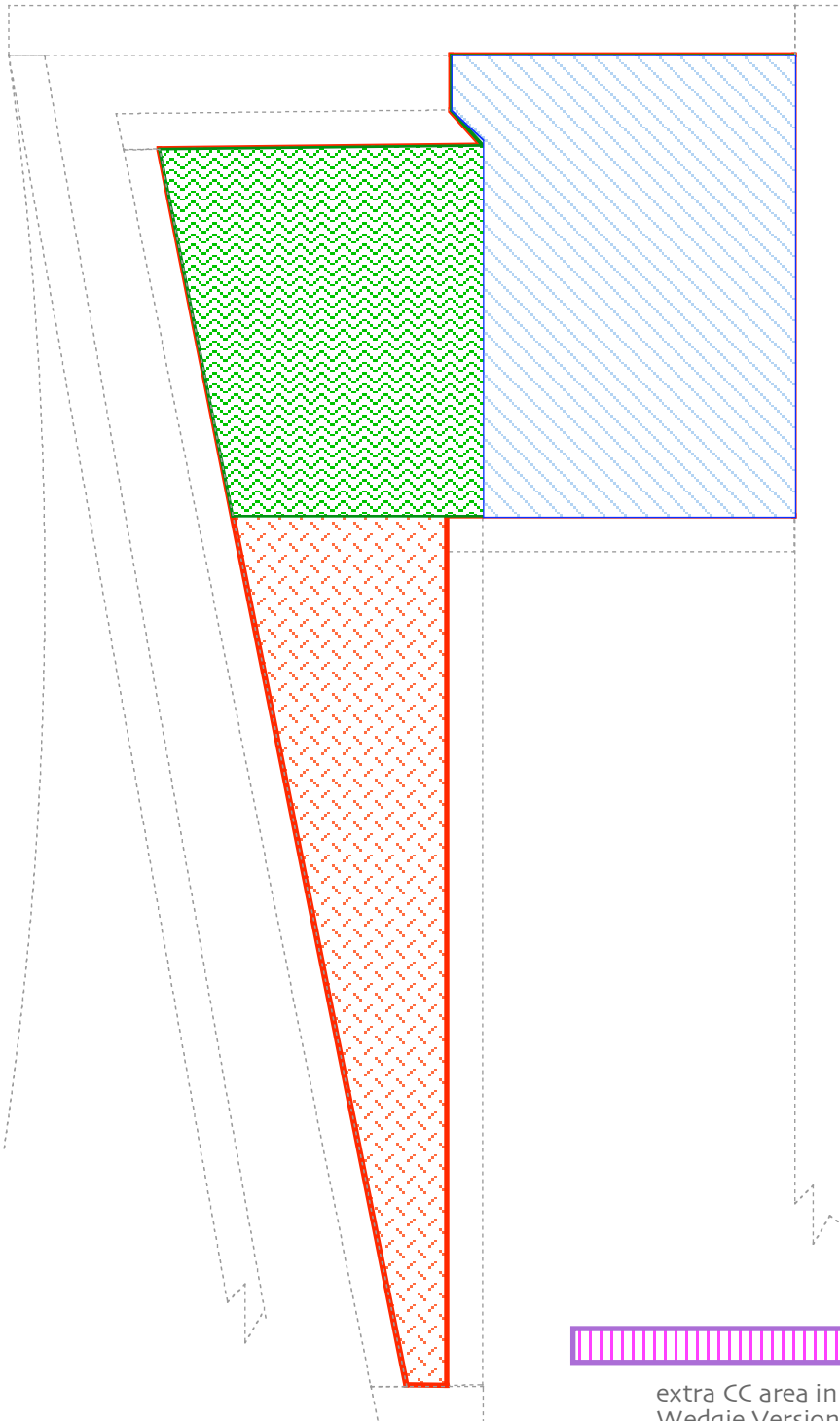
The Frugel-Horn
Open Source Corner Horn
Project V1.0 sheet FH4
Side Pattern (1/2" grid)
drawn by dld
17-june-2006



The Frugel-Horn
Open Source Corner Horn
Project V1.0 sheet FH5
Side Pattern (1 cm grid)
drawn by dld
17-june-2006



-  = small
(2.356 litre/143.7 in³)
-  +  = medium
(4.067 litre/248.1 in³)
-  +  +  = large
(5.854 litre/357.3 in³)
-  = extra volume added by wedgie version
(0.186 litre/11.36 in³)



0/ internal partitions readily allow 3 major sizes of compression chamber. Volumes indicated do not subtract volume of the back of the driver or any braces added

1/ the volume of the CC along with the throat size & the driver parameters create a low pass filter for output from the horn. The larger the CC volume the lower the filter's cut-off. It is important that this is not so high as to allow significant midrange to get to the horn (ie not too small), but not so low that the horn action isn't being used to ease the job of the driver in producing bass (not too big). The lower this high pass is set the larger the supraBaffle required

2/ choose a CC larger than you think you need and then add solid fill -- an opportunity to make inside quite irregular -- to tune the CC size. A set of wooden blocks or such would allow change in fixed steps

3/ as a generalization drivers with greater Vas & Qt will require a larger CC and will vary depending on atmospheric pressure.

4/ please report back your findings for the driver you use, these will help fellow builders fine tune their enclosures

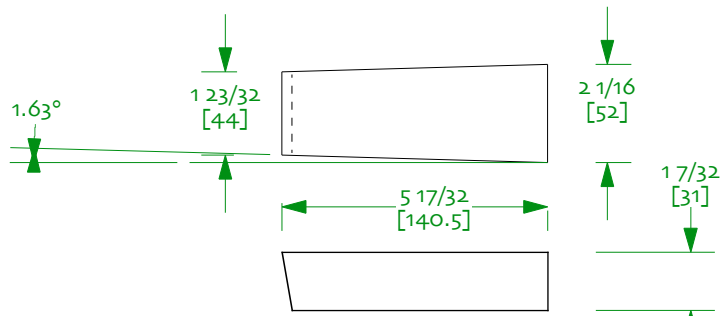
5/ The small CC is a good starting point for the FE126e & FE108eΣ

6/ The 1st approximation is 2.2 litre for the FE126e & 1.8 litre for the FE108eΣ

7/ If you do the wedgie version you start out with a slightly larger CC



extra CC area in Wedgie Version



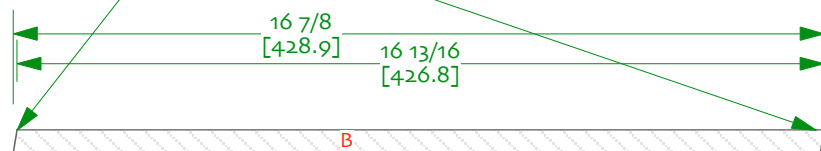
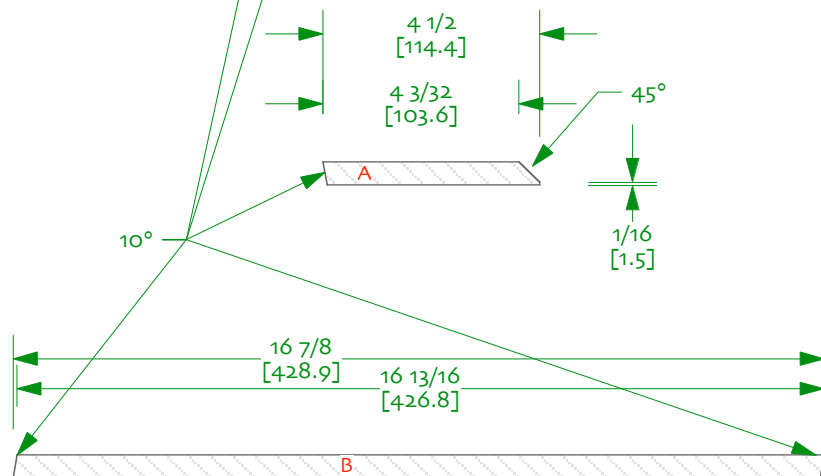
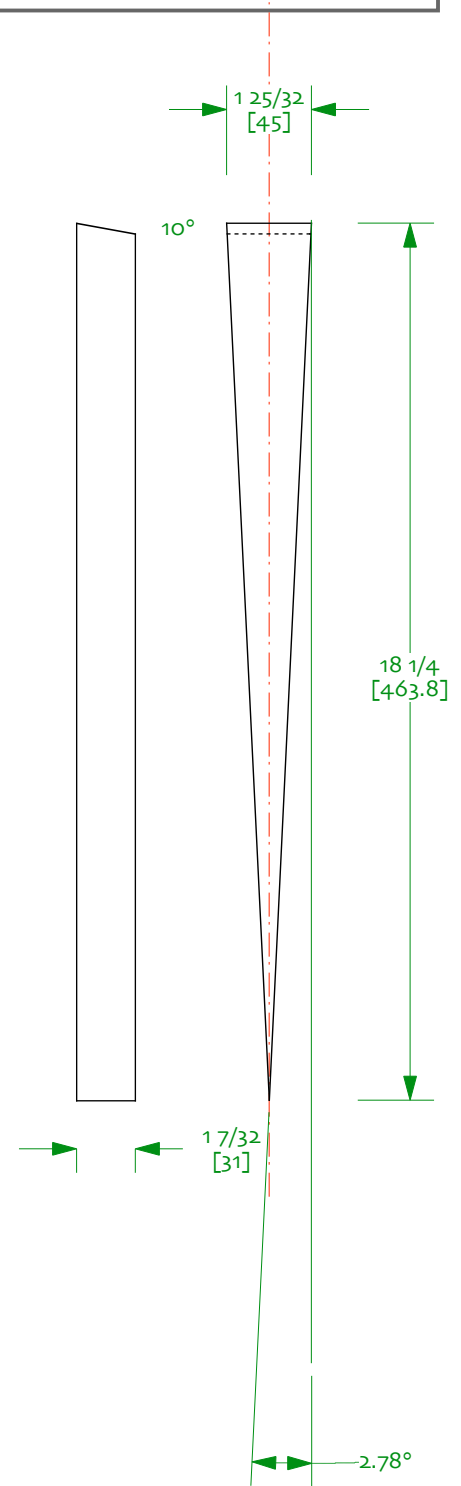
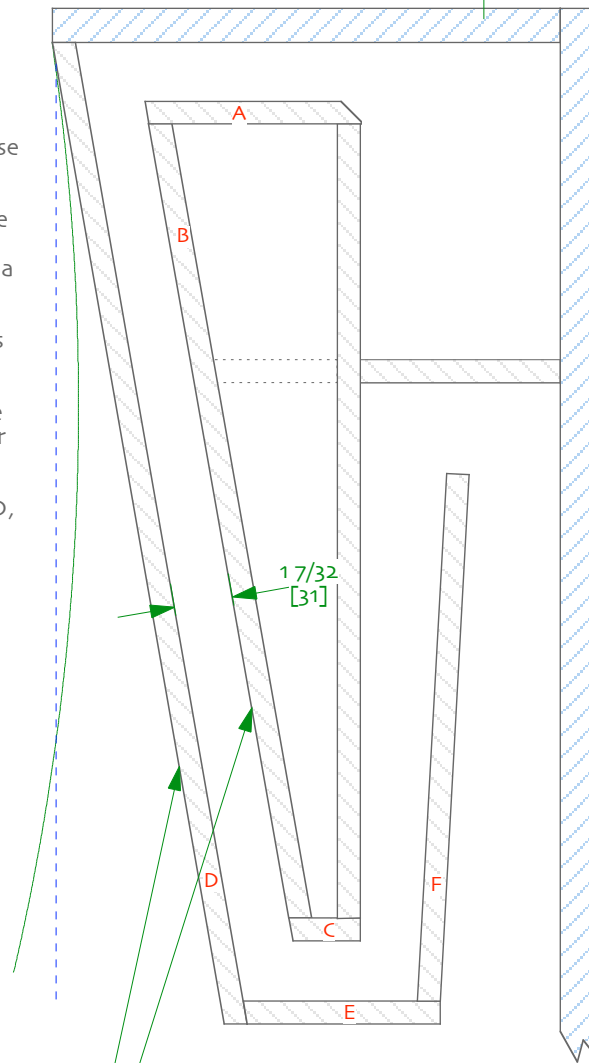
Notes:

0/ the "wedgie" comes from the use of 2 wedge shaped pieces to make the taper. The 1st 2 passages are fixed at 31mm wide and the wedge in the middle of each passage is used to taper the line. This allows a less severe cross-section ratio (2 channels with 1.4:1 aspect vrs 1 with an aspect of 7.5:1) and braces the high pressure panels.

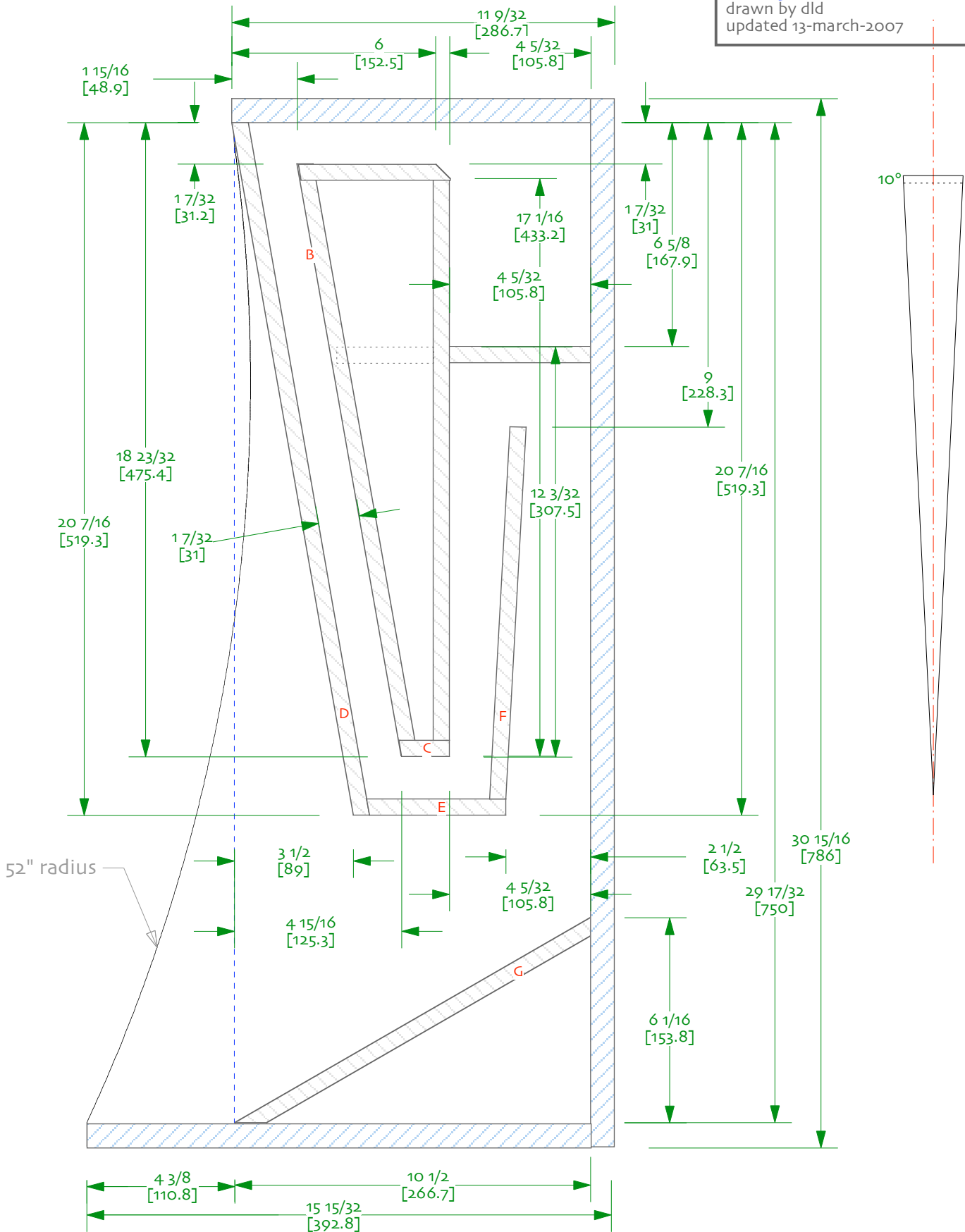
1/ the increase in the height of the 1st section requires a slightly taller box and a slightly deeper top.

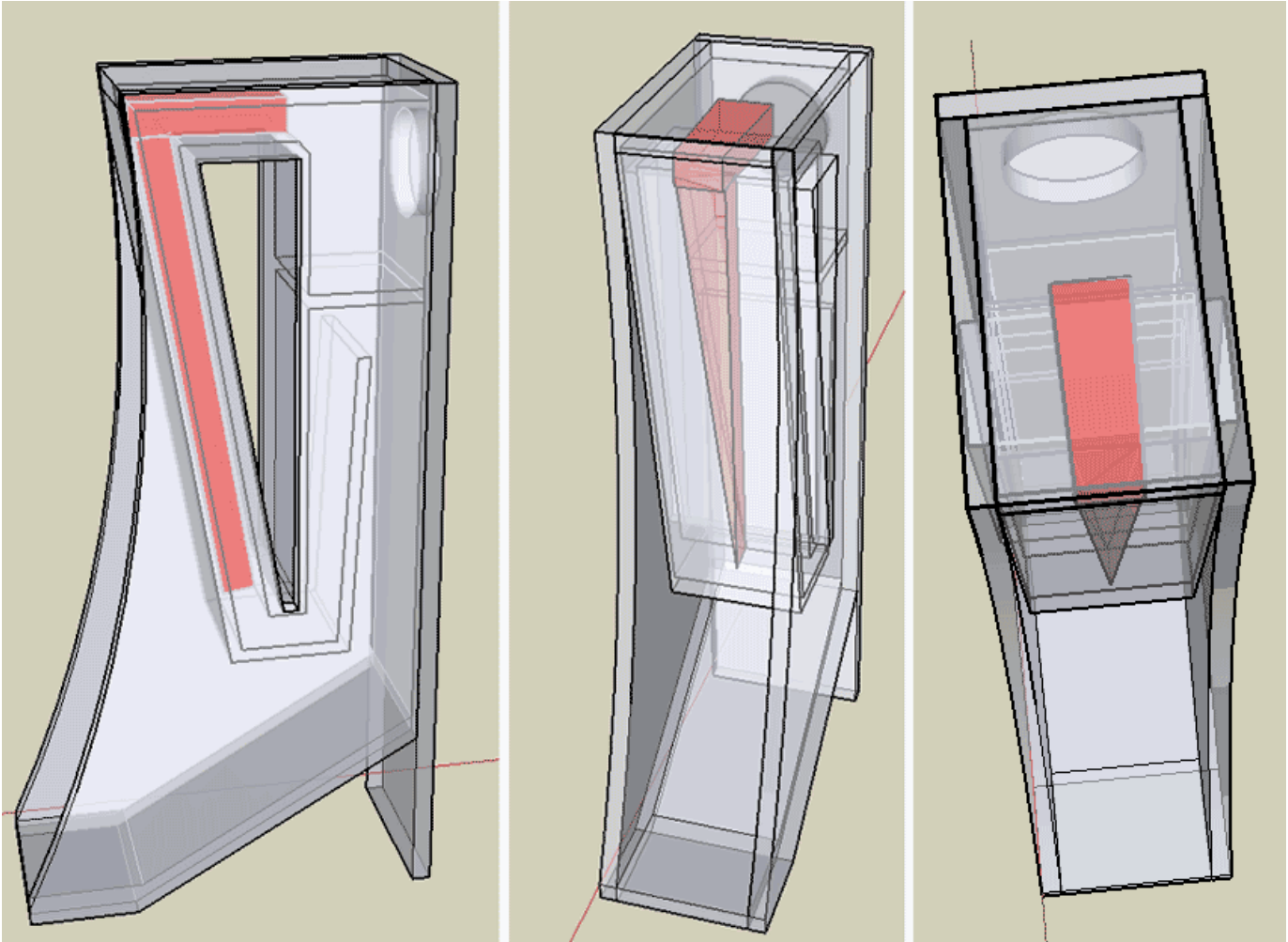
2/ all the angles in pieces A, B, C, D, & E are now 10°, 45° or 90°

3/ top, baffle, A, B, C, & D are different sizes. A & C aren't different by much.



The Frugel-Horn
 Open Source Corner Horn
 Project V1.ow sheet Ao-W1
Wedge Details
 drawn by dld
 updated 13-march-2007





Notes:

o/ red bits are the 2 wedgies

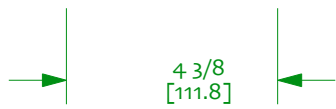
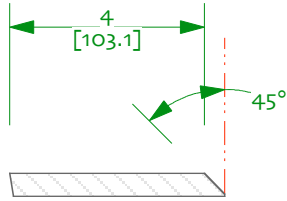
The Frugel-Horn
 Open Source Corner Horn
 Project V1.0w sheet Ao-W3
Internal Panel (Wedgie)
 drawn by dld
 14-august-2006

Notes:

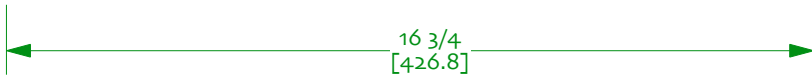
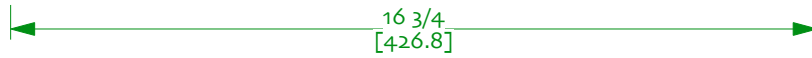
1/ all miters are 10° except for the one 90° cut & the marked 45°

2/ only panels that differ from the non-wedgie version shown

A



B



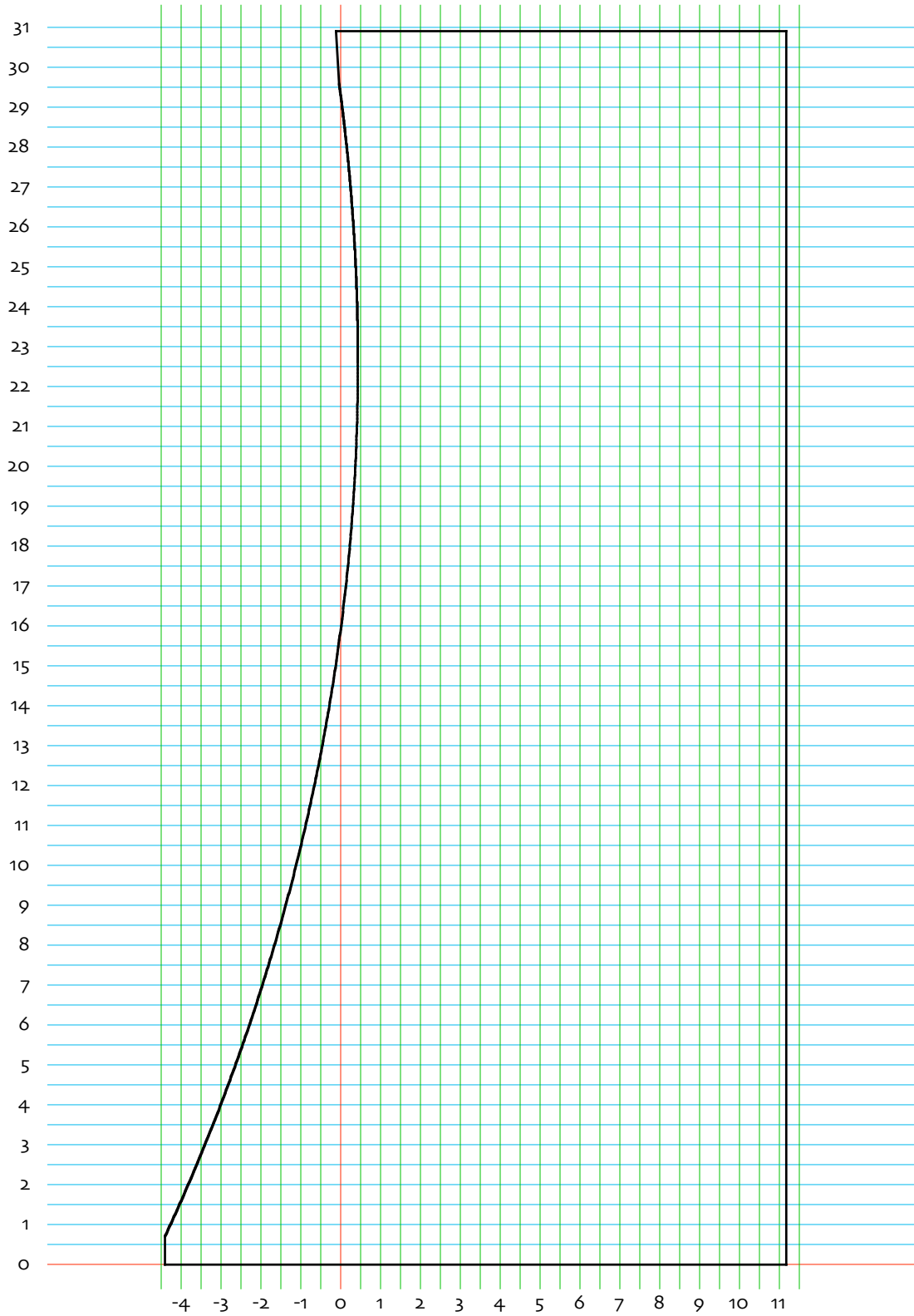
C



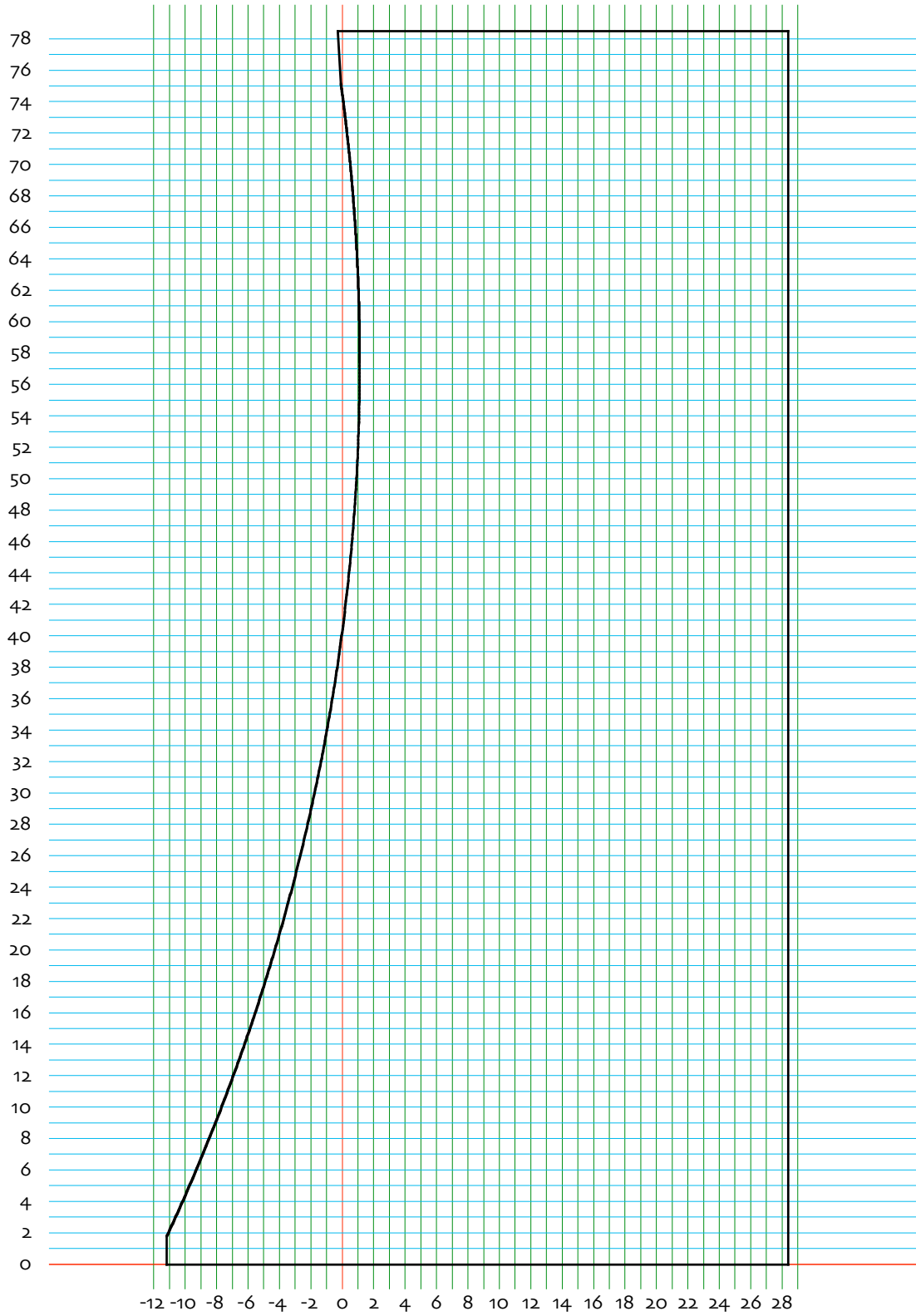
D



The Frugel-Horn
Open Source Corner Horn
Project V1.0w sheet Ao-W4
Wedgie Side Pattern (1/2" grid)
drawn by dld
09-october-2006



The Frugel-Horn
Open Source Corner Horn
Project V1.0w sheet Ao-W5
Wedgie Side
drawn by dld
09-october-2006



Notes:

The supraBaffle serves a specific purpose. Any speaker mounted on a baffle will see 2π steri-radians at high frequencies & 4π steri-radians at low frequencies. Ignoring any other influences this means an on-axis drop in level of 6 dB in the low frequencies. This is called baffle step loss*. With the narrow baffle of the Frugel-Horn this would start ~ 650-700 Hz. The output from the horn is high enough to compensate but only up to 250-300 Hz. The purpose of the supraBaffle is to push the baffle-step down in frequency until it meets up with the output from the horn. This depends on compression chamber size (ie the acoustic XO between the horn & the direct driver radiation), Exact values await actual measurements of units in the field.

*(for more info <http://www.t-linespeakers.org/tech/bafflestep/intro-bds.html>)

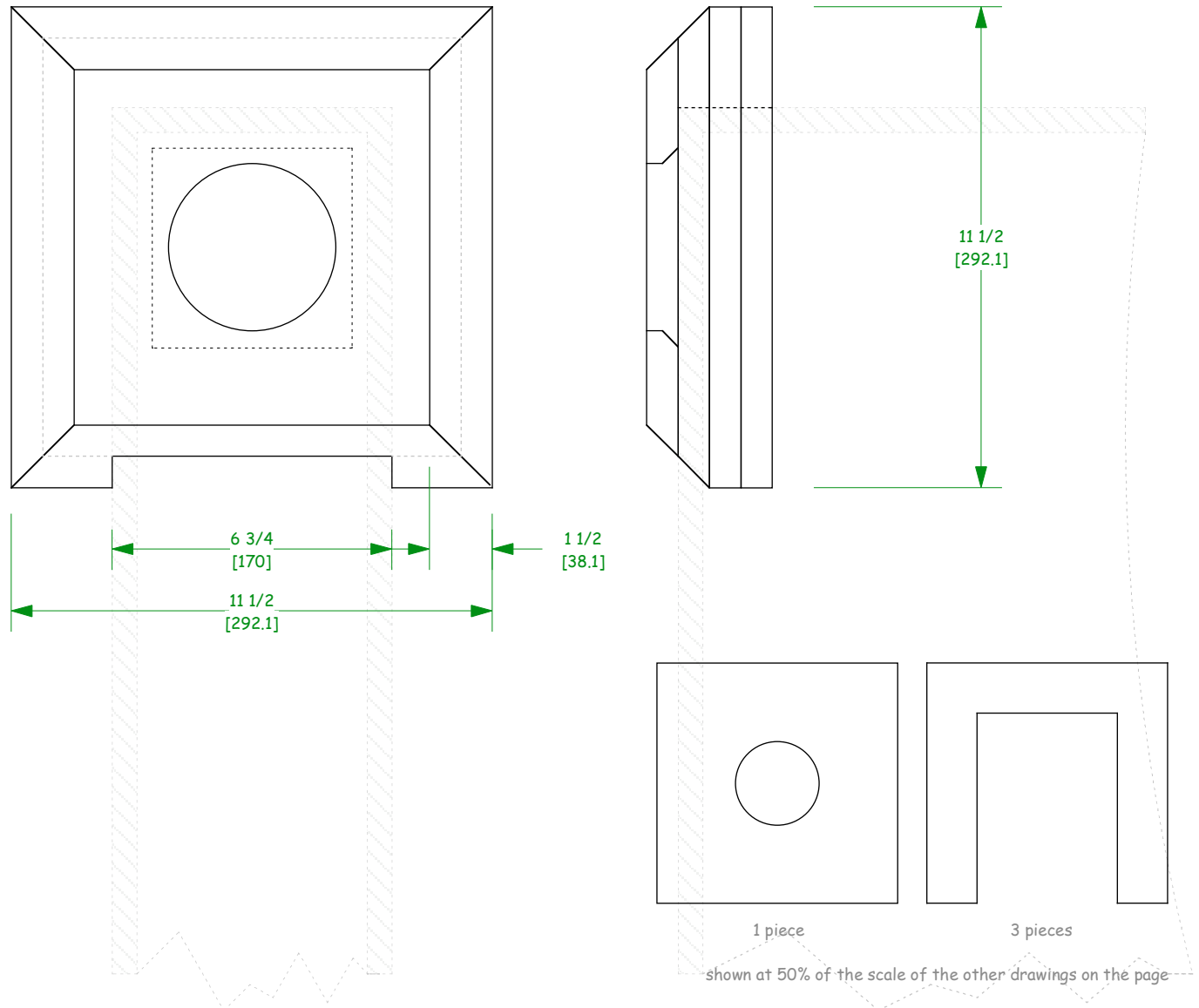
A 1st order approximation is that the supraBaffle needs to have an average minimum dimension of $11\ 1/2'$ -- $13"$ (292-330mm). The actual shape leaves a lot of room for creativity.

On the next sheet i have reproduced Page 23 of Olson's Acoustics and some shapes suggested or implemented already. This graphically illustrates the diffraction behaviour of a number of standard shapes. One can see that a sphere is smoothest, a truncated pyramid is close, and that any shape requires a trailing edge. From this, and ease of construction, a truncated pyramid will be designated as "the standard supraBaffle".

Considering work done since Olson, the shape that B&W uses on their top-of-range speakers for their midrange probably represents a close to ideal shape.

The supraBaffle can be flush with the front baffle, stand completely proud, or somewhere in-between. The standard sB will fit over the front, with most of the sB behind the plane of the front -- this because it is easiest to execute. Keep in mind that a supraBaffle proud of the front is going to increase the size of the suprabaffle.

This "standard supraBaffle" is comprised of 4 layers of $\sim 3/4"$ (19mm) material, and then passed thru a table saw with the blade set at 45° to achieve the bevel.



The Frugel-Horn
Open Source Corner Horn
Project V1.0 sheet A1-So
supraBaffles
drawn by dld
04-october-2006

The most thumbed page in my copy of Olson's Acoustics -- everybody should have a copy of this book (available from audioXpress).

It shows the baffle step diffraction on various shape baffles. It can be very helpful deciding what not to do.

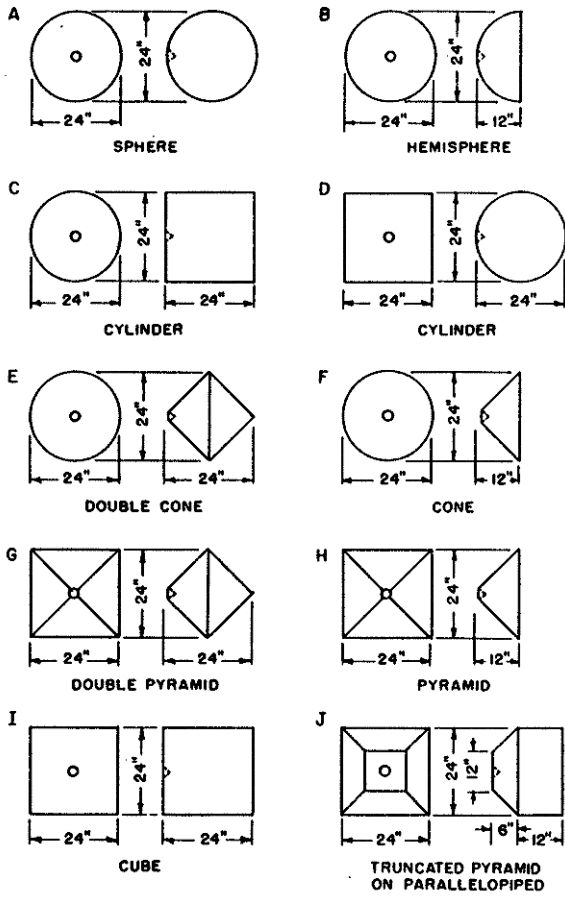


FIG. 1.9. Structures used in sound diffraction studies.

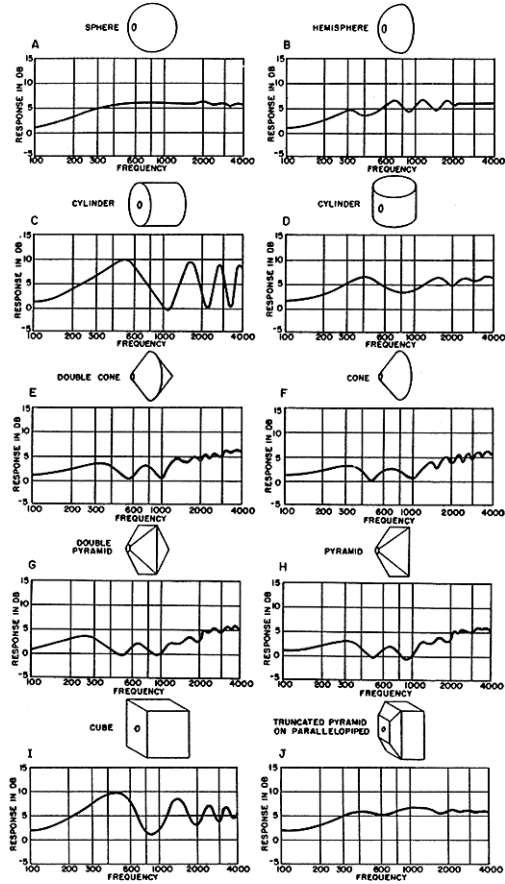
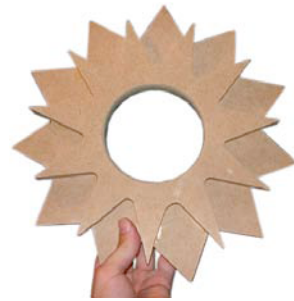
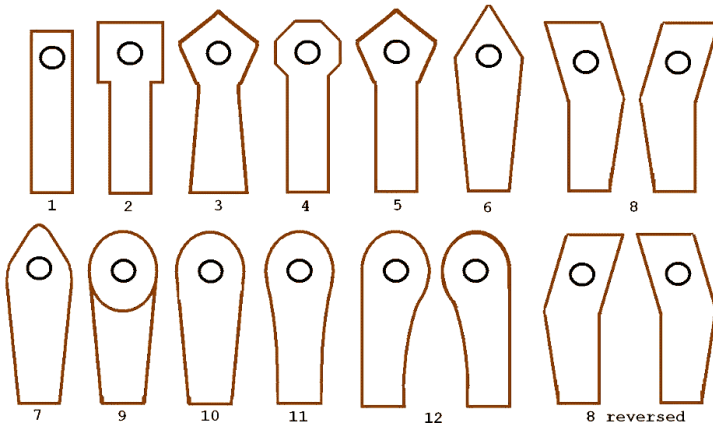
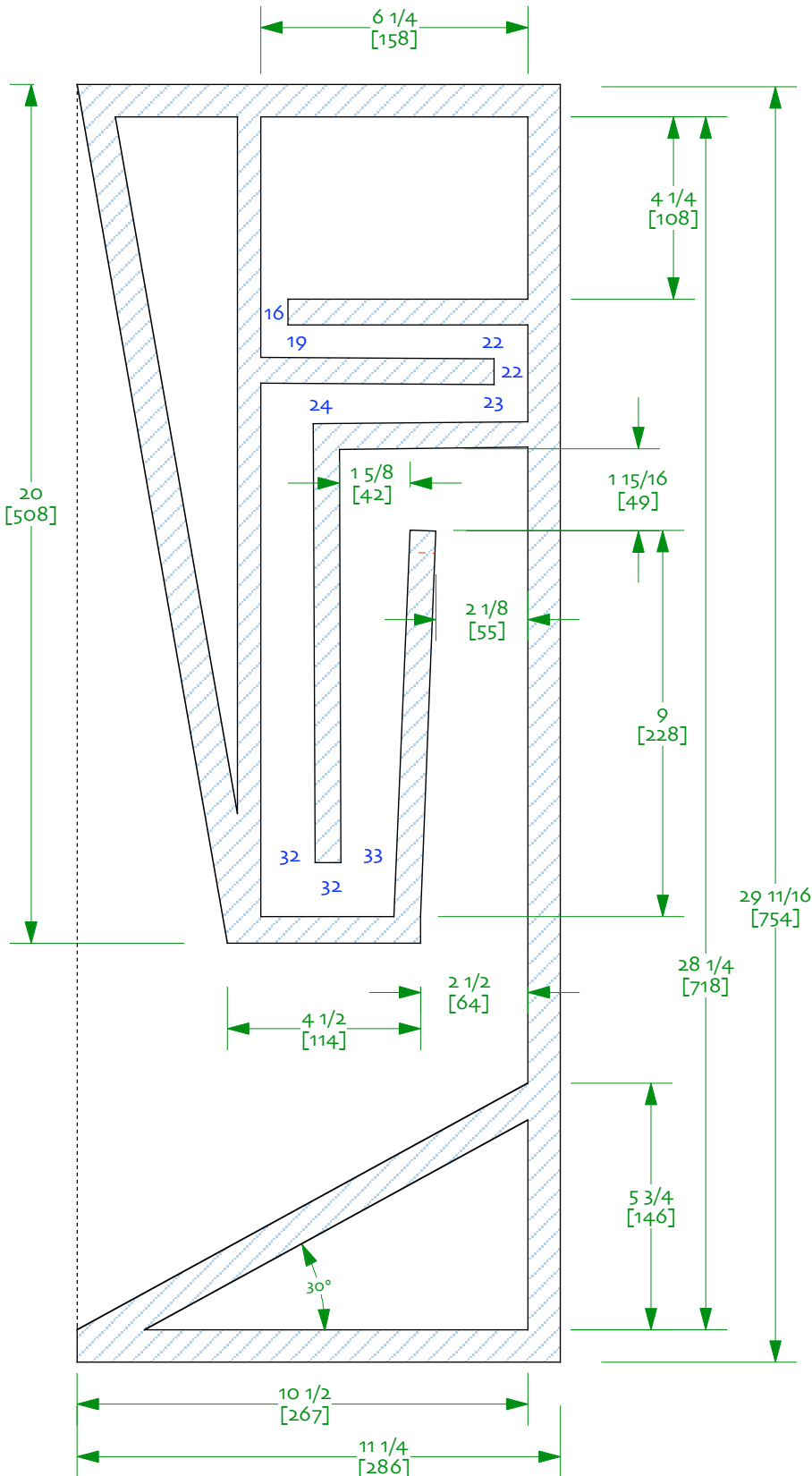


FIG. 1.10. Response frequency characteristics depicting the diffraction of sound by ten objects of different shapes. The dimensions of the objects are given in Fig. 1.9.

John in Costa Rica provided these sketches of possible supraBaffle shapes.



Josh's star shaped supraBaffle & the Nautalus midrange pod



Modified Buschhorn sheet A2-Bo
 a Buschhorn 1 stretched to fit a 4" (100mm) driver
 drawn by dld
 15-february-2006

0/ Internal width is $5 \frac{1}{8}$ " (130mm)

1/ internal partitions are $5 \frac{5}{8}$ " (155mm)

2/ this was what we built as proof of concept, ie Version Zero. All subsequent builds have been superior, so this is only here for historic interest.