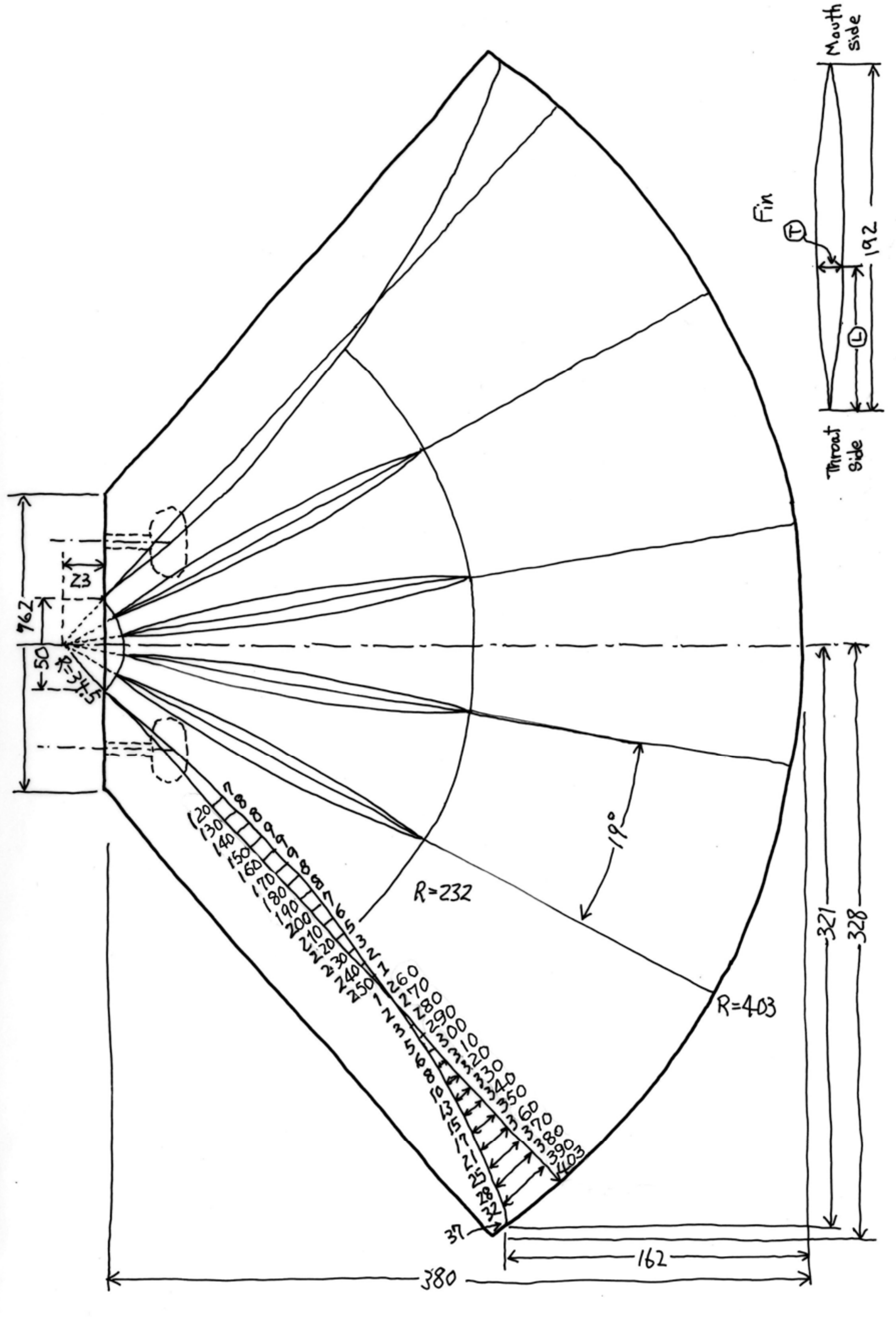
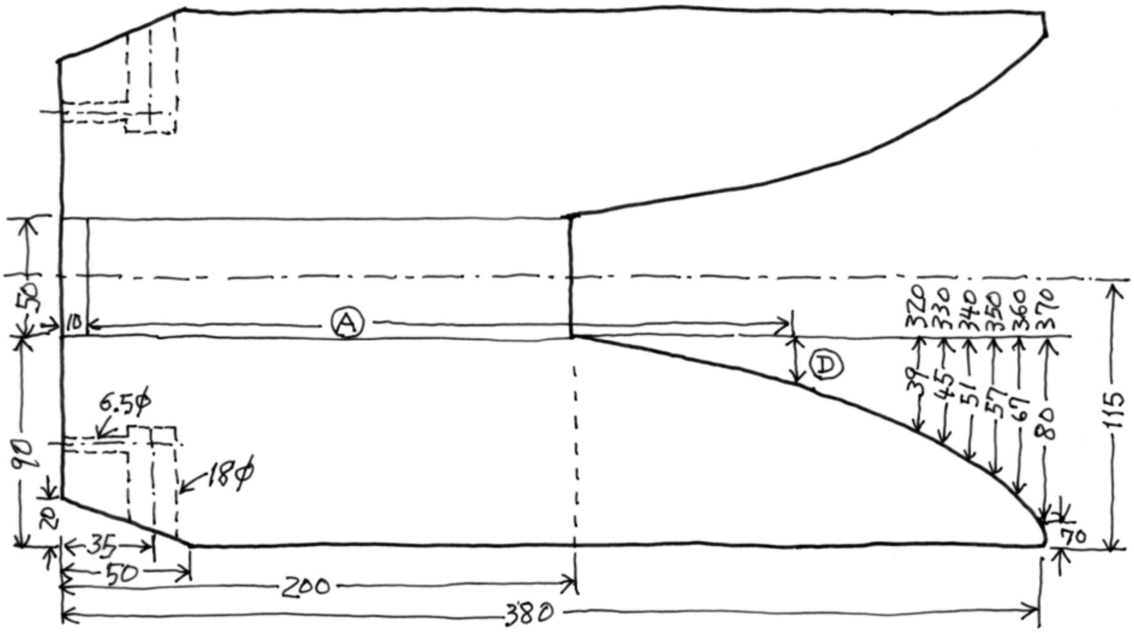
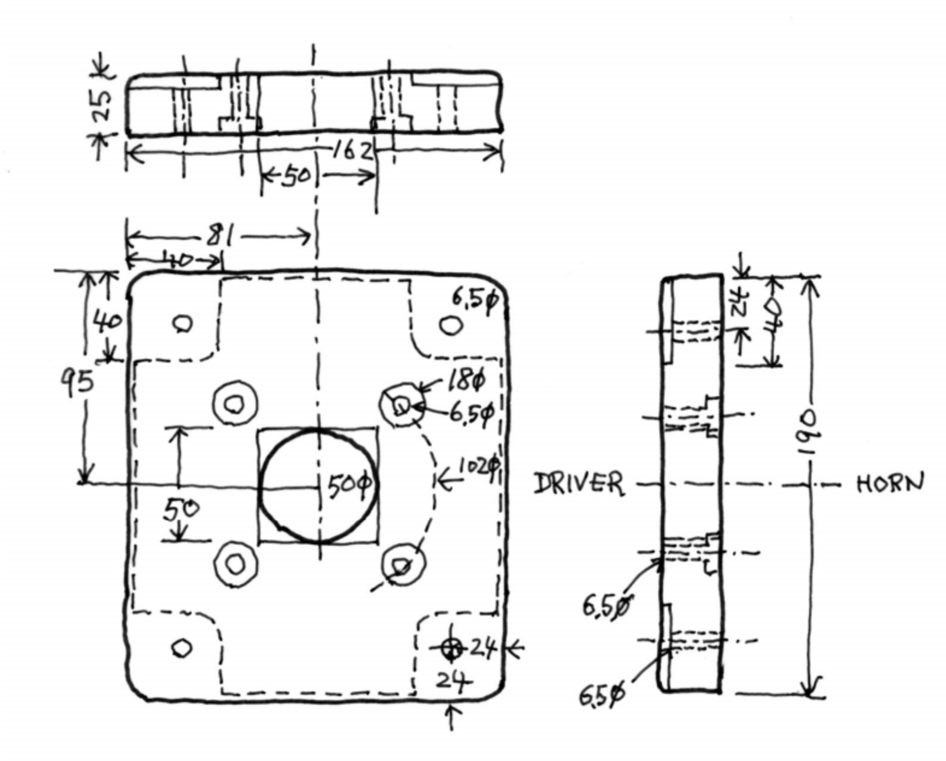
A-290 Wood Horn Drawing



Cross section of A-290 Horn



Driver Adapter



Horn Curve

(A)mm	(D)mm
0 ~	0.0
~ 190	0.0
200	1.5
210	3.3
220	5.2
230	7.4
240	9.7
250	12.3
260	15.0
270	18.1
280	21.4
290	25.1
300	29.1
310	33.5
Beyond 310	Refer drawing 1/3

Fin Curve

(L)	(T)
0	0.0
10	2.4
20	4.6
30	6.7
40	8.6
50	10.4
60	11.9
70	13.3
80	14.3
90	15.2
100	15.7
110	15.9
120	15.7
130	15.1
141	14.1
151	12.6
161	10.5
172	7.8
182	4.5
193	0.0

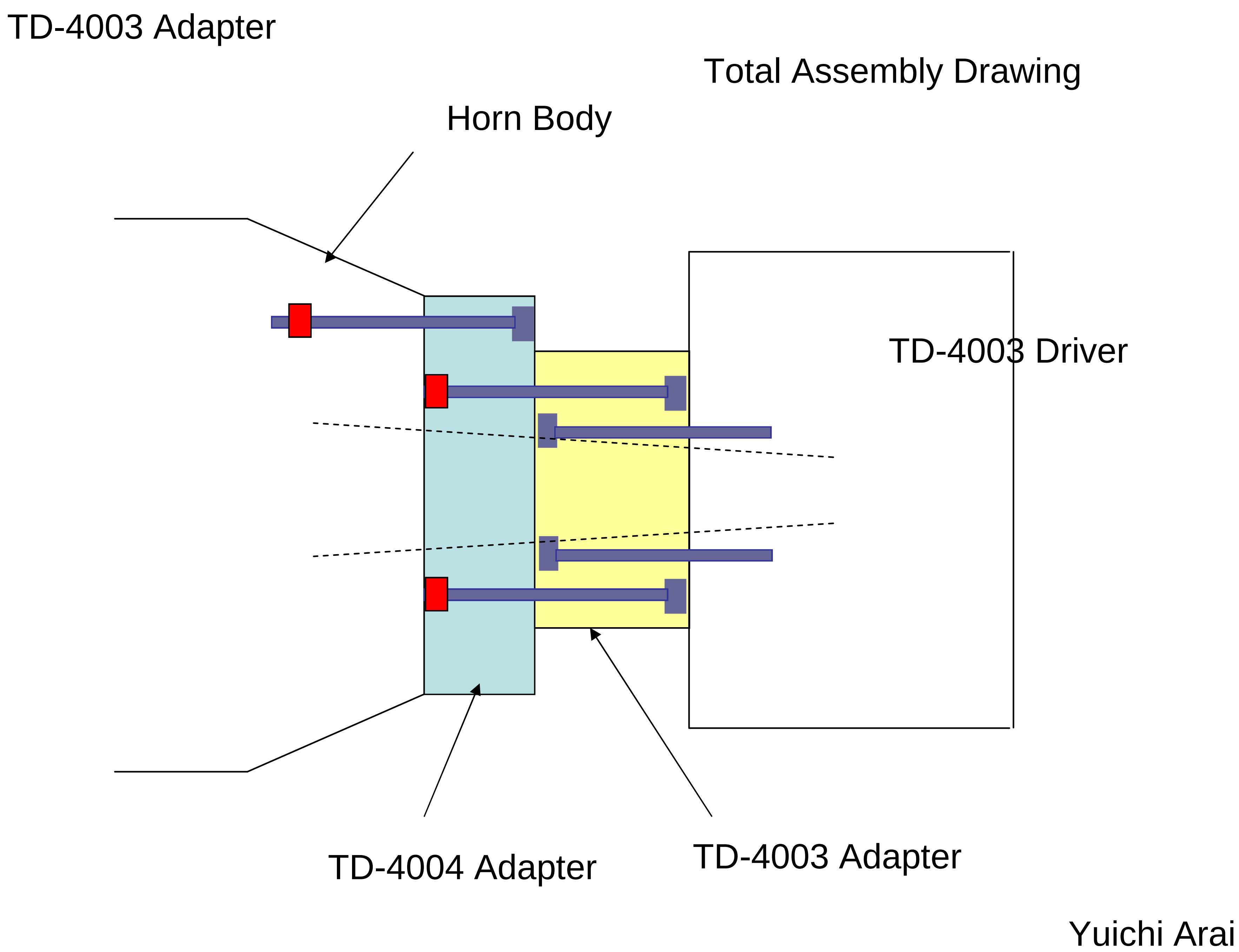
Note: All four fins are the same size.

Unit : mm

Wood Material : a Chinese quince laminated lumber (3.0cm thickness)

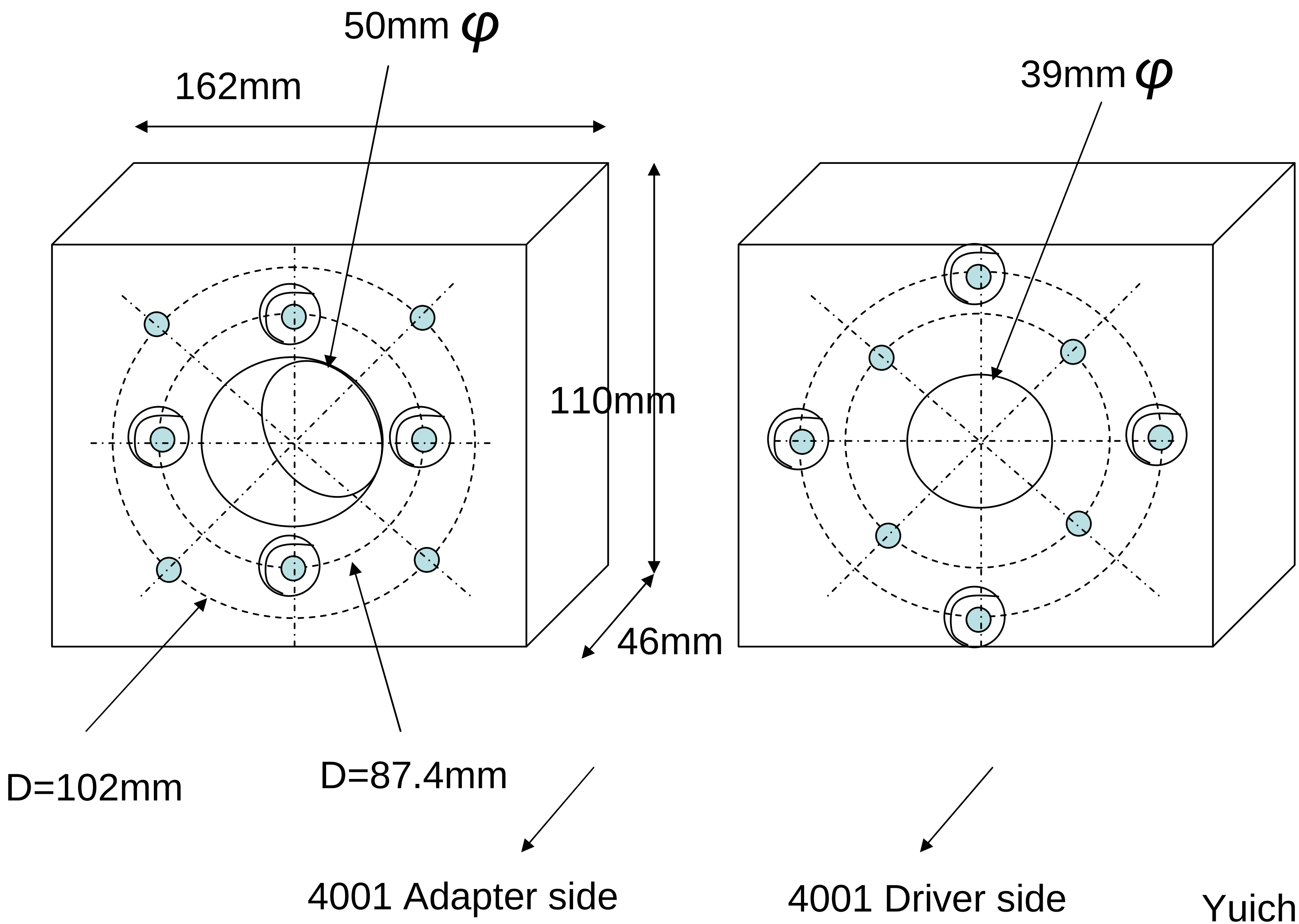
Driver : 2 inches throat driver (Pioneer TAD TD-4001 or JBL-2441, 2445)

Designed by Yuichi Arai (Refer to the March 1989 issue of MJ Magazine, Tokyo for detail.)



TD-4003 Adapter
Total Assembly Drawing
Horn Body
TD-4003 Driver
TD-4004 Adapter
TD-4003 Adapter
Yuichi Arai

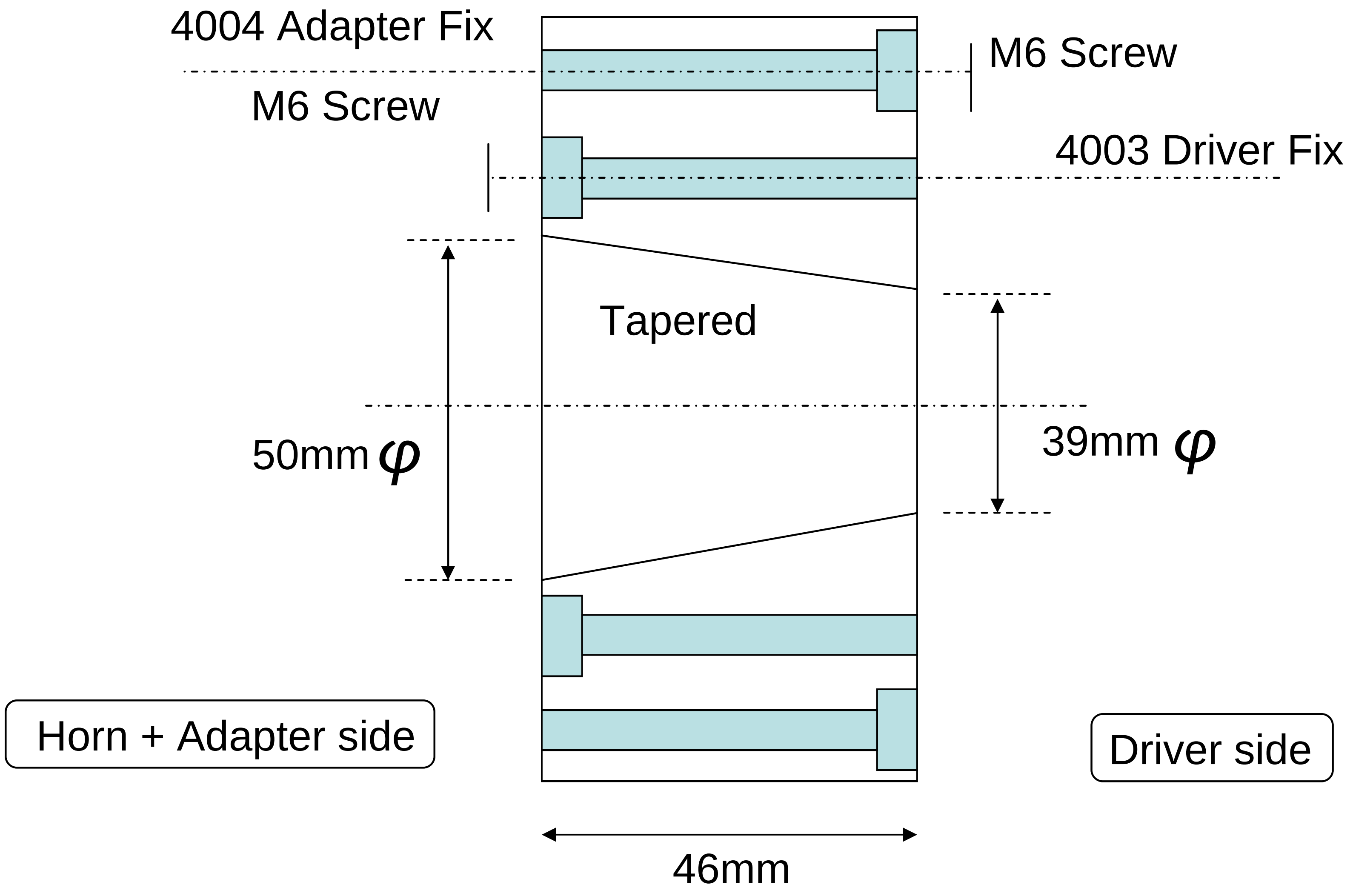
TD-4003 Adapter Drawing



Yuichi Arai

TD-4003 Adapter Cross section

All screws are M6 size.

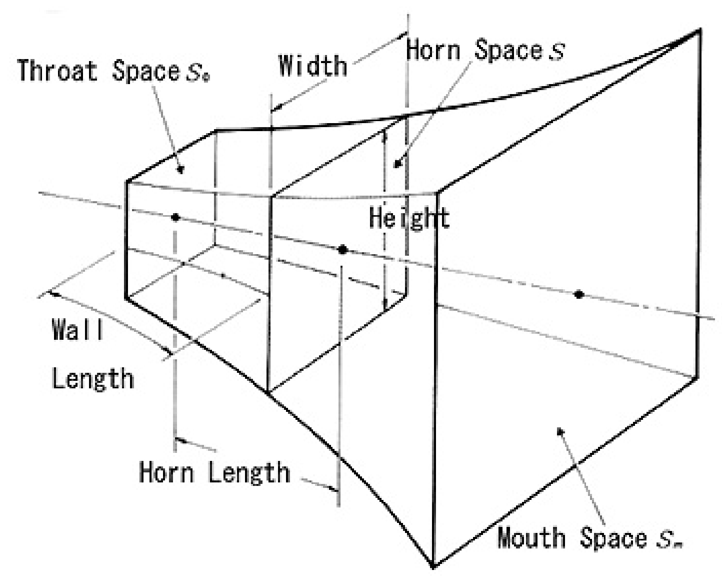


Yuichi Arai

http://www.geocities.jp/arai401204/Horn/HornDesign/Experiment.html

http://www.geocities.jp/arai401204/Horn/A290S/A290-S90.html
http://www.geocities.jp/arai401204/Horn_Page/Horn_Speakers.html
http://www.geocities.jp/arai401204/Horn/A290FL/A290FL.html
http://www.geocities.jp/arai401204/Horn/A300E/A300E.html
http://www.geocities.jp/arai401204/Drawings/A300E/A300E.pdf
http://www.geocities.jp/arai401204/Drawings/A290FL/A-290FL_Dwg.pdf
http://www.geocities.jp/arai401204/Drawings/A290S/A290-s.pdf
http://www.geocities.jp/arai401204/Drawings/A290/A290.pdf

This is not a perfect design guide, but gives you some idea to generate the Horn contour. Originally I wanted to build a good Horn speaker. Unfortunately I could not find out good design guide which matches to my willing. So, I made may own calculation system long time ago. However, the Horn system exists still in the high end market today. Which means that there is still some DAY funs in this space. This is the reason why I summarize how to design the horn from my book which was published long time ago. Please refer the idea how to generate the horn design such as A-290 but not to look at details. I have no confidence about the consistency in detail numbers.



The horn expands its horn space (S) from the throat position (So) to the mouth (Sm). "How it expands"? depends upon the equation which is so called horn type. Which includes the "Exponential", "Hyperbolic", "Cone" and "Tractric". Since the Tractric horn expands its horn space up until the infinite baffle, its horn length is limited. Other horns have unlimited horn length. Therefore, we cut the horn length intentionally because we can not make it.

Here, we discuss about the hyperbolic horn which has nicer capability than the exponential horn. In reality, the exponential horn is one of the hyperbolic horn. In any way, left fig. shows the naming of each part of the horn.

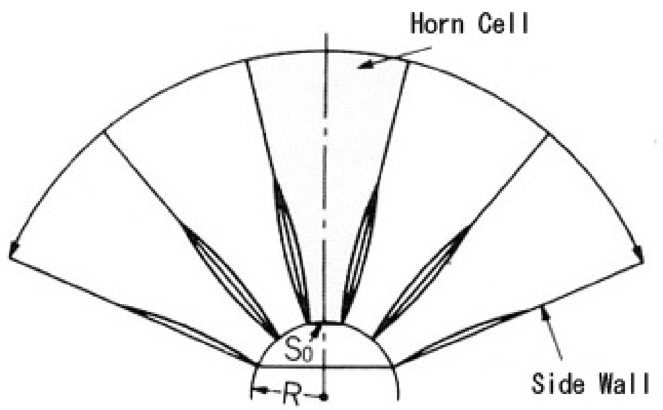
Horn Length (cm)	Horn Space (cm^2)	Horn Width (cm)	Horn Height (cm)	Wall Length (cm)
0.0	100.0	10.0	10.0	0.0
2.0	109.9	10.5	10.5	2.0
4.0	122.1	11.0	11.0	4.0
6.0	136.9	11.7	11.7	6.1
8.0	154.7	12.4	12.4	8.1
10.0	175.7	13.3	13.3	10.1
12.0	200.6	14.2	14.2	12.2
14.0	229.7	15.2	15.2	14.2
16.0	263.7	16.2	16.2	16.3
18.0	303.4	17.4	17.4	18.4
20.0	349.5	18.7	18.7	20.5
22.0	403.1	20.1	20.1	22.6
24.0	465.4	21.6	21.6	24.8
26.0	537.6	23.2	23.2	26.9
28.0	621.3	24.9	24.9	29.1
30.0	718.3	26.8	26.8	31.3
32.0	830.7	28.8	28.8	33.5
34.0	960.8	31.0	31.0	35.8
36.0	1111.5	33.3	33.3	38.1
38.0	1285.9	35.9	35.9	40.5
40.0	1487.8	38.6	38.6	42.9
42.0	1721.6	41.5	41.5	45.4
44.0	1992.2	44.6	44.6	47.9
46.0	2305.4	48.0	48.0	50.6
48.0	2667.9	51.7	51.7	53.3
50.0	3087.5	55.6	55.6	56.1
52.0	3573.1	59.8	59.8	59.0
54.0	4135.1	64.3	64.3	62.0
56.0	4785.5	69.2	69.2	65.1

$$S = So(Cosh \cdot m \bullet x + T \bullet Sinh \cdot m \bullet x)$$

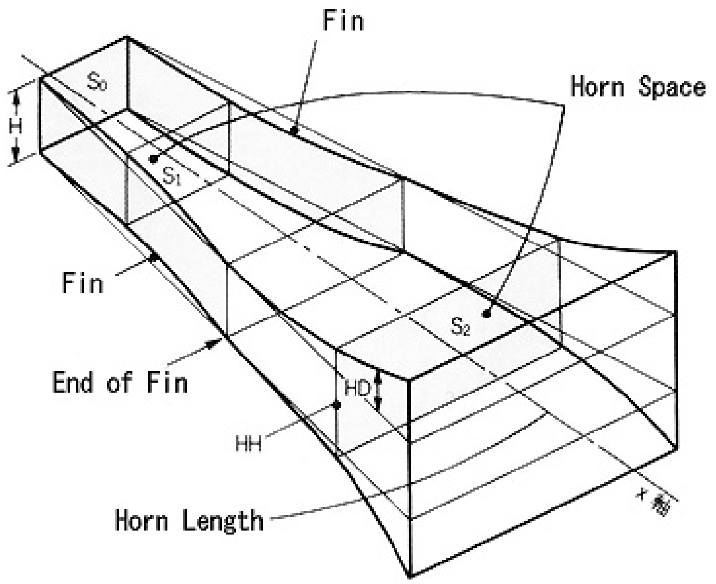
$$m = \frac{4\pi \bullet Fc}{c}$$

Where x=Horn Length from the throat

You can find out the equation of the hyperbolic contour in the text book such as above. In the equation I assumed as follows to make it simple.
Horn width = Horn Height
Fc=200Hz, T=0.6 (flat frequency response) T=1 generates the exponential horn.
The calculation is as shown in the left. First the Horn space is calculated to the horn length. The horn length is endless. However, there is conventional equation to cut the horn length which came from Fc (cut off frequency Hz) or wave length. In this case the horn length is 48cm or the mouth space 2668 cm^2. This size creates the minimum impacts of the acoustic impedance from the mouth area. We call this as a full size horn.



Now we can design the horn system. The reason why the A-290 has several fins inside is as follows. Without fins the high frequency sound over 8KHz concentrates in the center of the horn. Therefore, the separator is important to have flat frequency response to provide wider service area in front of the Horn. Just thin separators will creates some problems. Therefore, the fins has to be reasonably robust.
Then,.....we assumed that the A-290 type horn consists of several Horn cells or sub horns as illustrated in the left fig.
So, from now on, we consider to calculate single horn cell. The summation of horn cells follow the equation (S). How many horn cells we I have, is totally up to us, but there is not so much freedom available. So, we have to do "cut and try" many times on the computer.

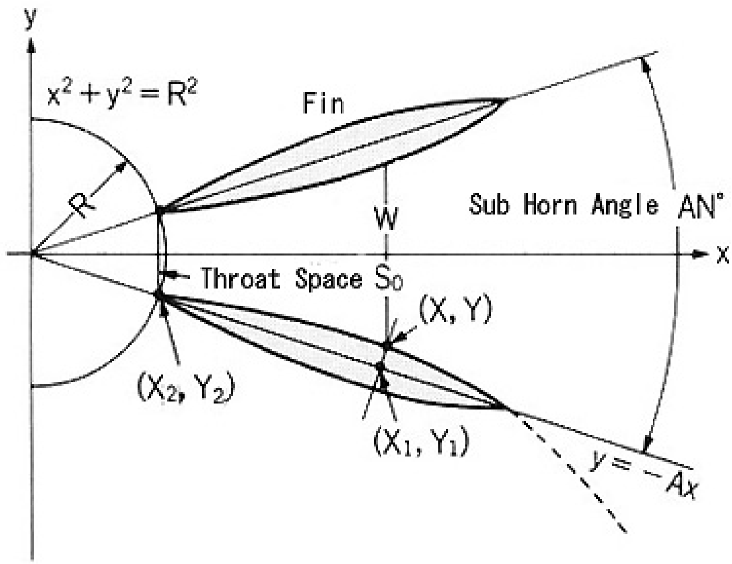


A-290 Design

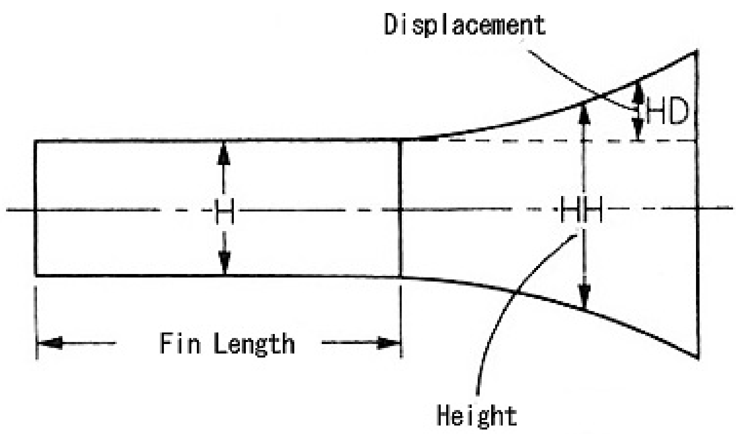
Left fig. shows a model of single horn cell. In this case, above horn consists of five small horn cells. A horn cell consists of two horn space expansion mode, S1 and S2.

The horn cell starts from throat space (So) with height (H). The height (H) stays the same until the end of the Fin. In this area Horn space (S1) belongs to radial expansion of both side wall minus thickness of the fins.

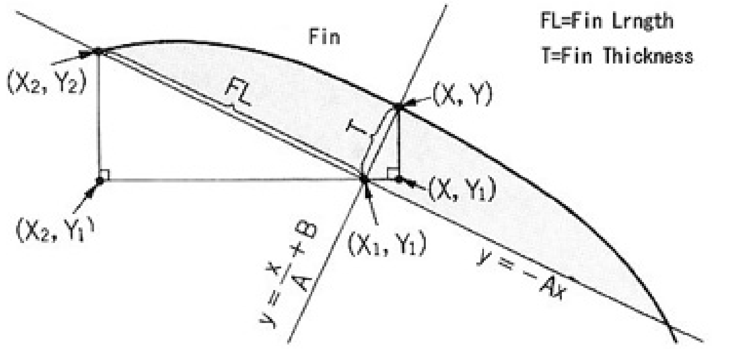
After the end of the fin location, the Horn space (S2) follows the radial expansion of side walls and expansion of the height (HD*2). So, the S1 and S2 expand the space in deferent ways. Smooth transition between S1 and S2 is important. So, thicker fin is good for mechanical point of view but not good for acoustic point.



This is the top view of single horn cell or a sub horn. Each horn cell is to be aligned with angle AN. The center horn cell starts from X2. And each throat of the horn cell is located on circle R. It is easy to understand the factors of horn space expansion horizontally. The contribution factors are the radial expansion and the thickness of the fins up until the end of the fin area.



This is the side view of the horn cell or the sub horn. It is easy to understand the factors of horn space expansion vertically. In the fin area, the contribution to the horn space is horizontal only because the height (H) stays the same. After the fine ended, displacement of the horn height (HD) complement the radial expansion to keep S2.



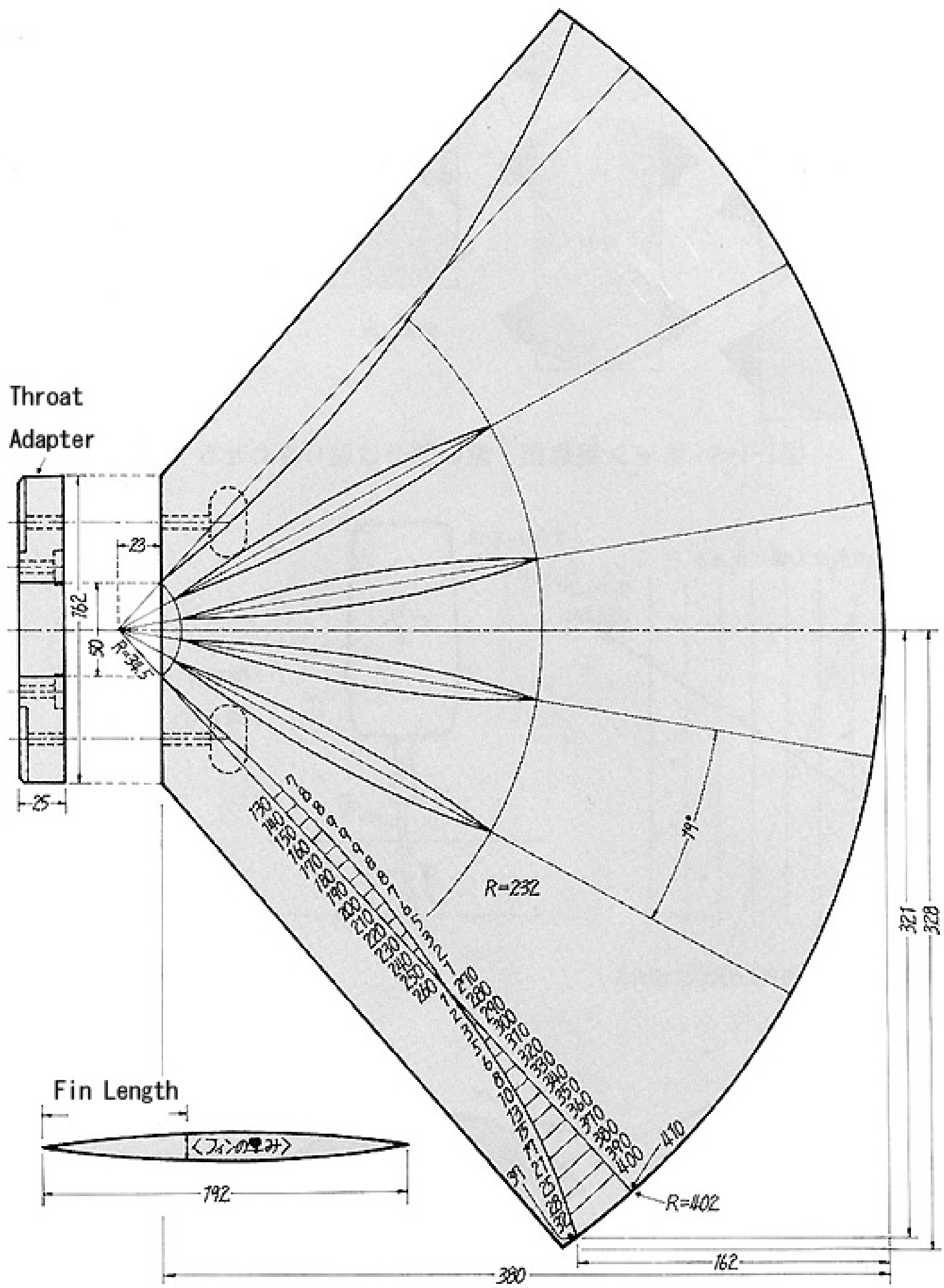
This is the cross section of the fin. On this chart, "T" means half of the fin thickness. Therefore, T*2 is the thickness.

HL (cm)	HS (cm.cm)	HH (cm)	HD (cm)	W (cm)	W/2 (cm)	T*2 (cm)	T (cm)	FL (cm)
0.0	5.69	5.00	0.00	1.14	0.57	0.00	0.00	0.00
1.0	6.16	5.00	0.00	1.23	0.62	0.24	0.12	0.99
2.0	6.69	5.00	0.00	1.34	0.67	0.46	0.23	1.99
3.0	7.30	5.00	0.00	1.46	0.73	0.67	0.34	2.99
4.0	8.00	5.00	0.00	1.60	0.80	0.86	0.43	3.98
5.0	8.79	5.00	0.00	1.76	0.88	1.04	0.52	4.98
6.0	9.68	5.00	0.00	1.94	0.97	1.19	0.60	5.98
7.0	10.68	5.00	0.00	2.14	1.07	1.33	0.66	6.99
8.0	11.80	5.00	0.00	2.36	1.18	1.43	0.72	7.99
9.0	13.06	5.00	0.00	2.61	1.31	1.52	0.76	9.00
10.0	14.47	5.00	0.00	2.89	1.45	1.57	0.78	10.01
11.0	16.04	5.00	0.00	3.21	1.60	1.59	0.79	11.02
12.0	17.80	5.00	0.00	3.56	1.78	1.57	0.79	12.04
13.0	19.76	5.00	0.00	3.95	1.98	1.51	0.76	13.05
14.0	21.95	5.00	0.00	4.39	2.20	1.41	0.71	14.08
15.0	24.40	5.00	0.00	4.88	2.44	1.26	0.63	15.10
16.0	27.12	5.00	0.00	5.42	2.71	1.05	0.53	16.13
17.0	30.15	5.00	0.00	6.03	3.02	0.78	0.39	17.17
18.0	33.53	5.00	0.00	6.71	3.35	0.45	0.22	18.21
19.0	37.30	5.00	0.00	7.46	3.73	0.03	0.02	19.26
20.0	41.49	5.30	0.15	7.83	3.91	0.00	-0.23	0.00
21.0	46.16	5.66	0.33	8.16	4.08	0.00	-0.53	0.00
22.0	51.37	6.04	0.52	8.50	4.25	0.00	-0.88	0.00
23.0	57.16	6.47	0.74	8.83	4.42	0.00	-1.28	0.00
24.0	63.61	6.94	0.97	9.17	4.58	0.00	-1.75	0.00
25.0	70.78	7.45	1.23	9.50	4.75	0.00	-2.30	0.00
26.0	78.78	8.01	1.50	9.84	4.92	0.00	-2.92	0.00
27.0	87.67	8.62	1.81	10.17	5.09	0.00	-3.63	0.00
28.0	97.58	9.29	2.14	10.50	5.25	0.00	-4.44	0.00
29.0	108.60	10.02	2.51	10.84	5.42	0.00	-5.37	0.00
30.0	120.87	10.82	2.91	11.17	5.59	0.00	-6.41	0.00
31.0	134.53	11.69	3.35	11.51	5.75	0.00	-7.59	0.00
32.0	149.74	12.64	3.82	11.84	5.92	0.00	-8.93	0.00
33.0	166.67	13.69	4.34	12.18	6.09	0.00	-10.43	0.00
34.0	185.51	14.83	4.91	12.51	6.26	0.00	-12.13	0.00
35.0	206.48	16.07	5.54	12.85	6.42	0.00	-14.03	0.00
36.0	229.83	17.44	6.22	13.18	6.59	0.00	-16.17	0.00
37.0	255.81	18.93	6.96	13.52	6.76	0.00	-18.57	0.00
38.0	284.73	20.56	7.78	13.85	6.92	0.00	-21.25	0.00
39.0	316.93	22.34	8.67	14.18	7.09	0.00	-24.26	0.00
40.0	352.76	24.30	9.65	14.52	7.26	0.00	-27.63	0.00

This is the calculation of single cell where...
HL=Horn Length,
HS=Horn Space,
HH=Horn Height,
HD=Horn Height Displacement,
W=Width,
T*2=thickness of the Fin,
FL=Fin Length

The Fin Length longer than 19.26 is invalid because the fin thickness (T*2) becomes zero.

The length of the horn cell is 37cm. This does not 100% match to the horn length. This is because of mismatch between throat positions of the horn cell and the horn.

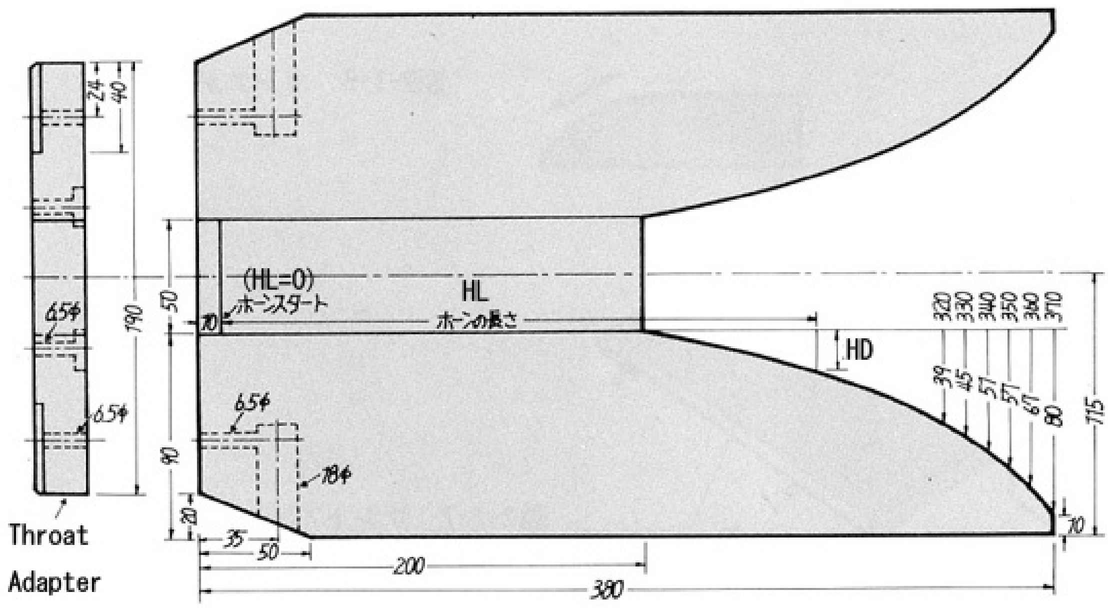


Above is the calculations. To do this, I cared about available size of wood materials, possibility of process, thickness of the fin, the mouth contour, side wall contour, angle of the horn, and other factors.

One other thing is how to fix the driver with square (four corners) mouth. It usually use the cast in the professional world. But for DAY way it is not applicable.

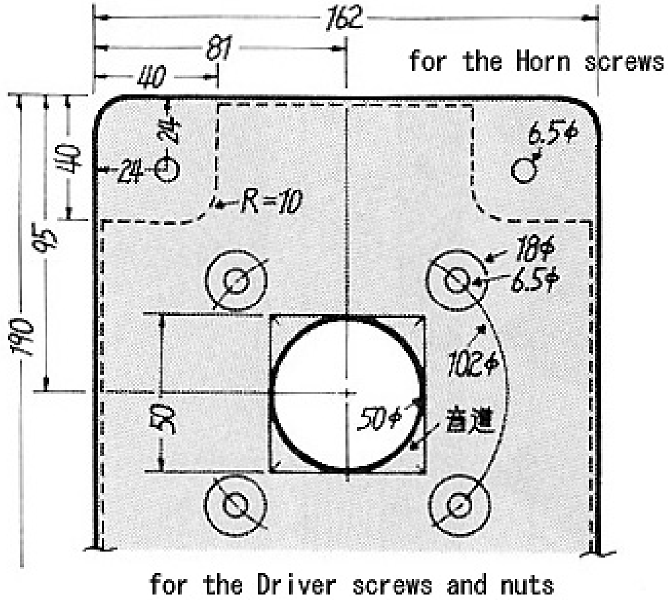
So, another "Try and error" processes contributed to generate the drawings. So, the size does not perfectly match to the calculations for smooth matching to the air at the mouth area and others.

Left is the top view of A-290 horn.



This is the side view of the horn. The thickness of the wood material at the mouth location keep 1cm to minimize vibration. The throat of the horn cell is located 1cm inside of the horn throat. This came from the drawing of the top view.

Four mounting holes are provided to fix the throat adapter.

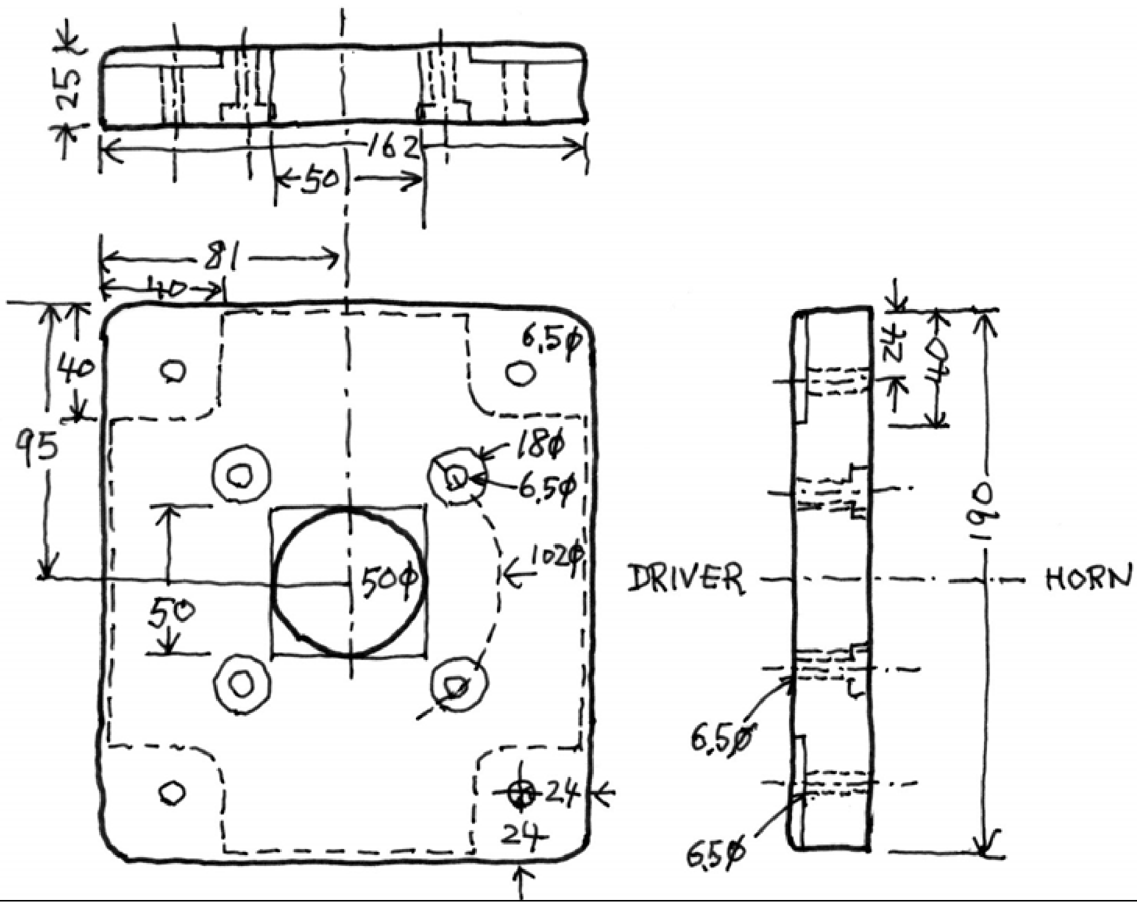


This is the drawing of the throat adapter. There are two requirements to this component.

One is to convert 5cm diameter driver space to 5cm x 5cm horn throat. This space expansion requires 2.5cm length of the horn. Therefore, I used 2.5cm thick hard wood.

One other purpose is to mechanically fixes the driver to the horn.

To perform these objectives, the throat adapter is designed.



Horn Curve

(A)mm	(D)mm
0 -	0.0
- 190	0.0
200	1.5
210	3.3
220	5.2
230	7.4
240	9.7
250	12.3
260	15.0
270	18.1
280	21.4
290	25.1
300	29.1
310	33.5
Beyond 310	Refer drawing 1/3

Fin Curve

(L)	(T)
0	0.0
10	2.4
20	4.6
30	6.7
40	8.6
50	10.4
60	11.9
70	13.3
80	14.3
90	15.2
100	15.7
110	15.9
120	15.7
130	15.1
141	14.1
151	12.6
161	10.5
172	7.8
182	4.5
193	0.0

Note: All four fins are the same size.

Unit : mm
Wood Material : a Chinese quince laminated lumber (3.0cm thickness)


FĂRĂ EGAL