



THE PA BIBLE

ADDITION NUMBER TWELVE "FORCE®" BOXES FOR MUSIC SYSTEMS

INTRODUCTION

In response to many requests for information on enclosures for our FORCE® music loudspeakers, we are publishing this twelfth addition of the PA Bible. In doing so, we will furnish curves showing the expected performance, plans for enclosures for the FORCE 10, FORCE 12 and FORCE 15, along with suggestions for constructing the cabinets.

The phrase "Boxes for Music Systems" in the title of this PA Bible addition refers to enclosures used for the bass section of sound reinforcement systems for live performances. These boxes are not intended to be home hi-fi or stereo systems.

The sound reinforcement system must have a higher average power handling capability in order to maintain the sound pressure levels in a club or auditorium environment, and must be able to handle the higher peak levels (dynamic range) of the live performance.

The home stereo system, on the other hand, is designed to reproduce material for the intimacy of the average home environment, where the power requirements for sufficient sound pressures levels and dynamic range are modest when compared to a live performance in a club or auditorium.

There are many different types of enclosures that can be used with music systems such as the acoustic suspension, folded horn, infinite baffle and the vented direct radiator (bass reflex), to name a few. Each has its advantage and disadvantage, depending on the application.

For this addition, we will consider vented enclosures based on Thiele parameters.

It wasn't until A. N. Thiele¹ developed his "alignments" that it became practical to mathematically predict or tailor the performance of a vented system to a specific application. Since then, much has been written on the subject of speaker system design and the mathematics involved in the actual enclosure/speaker relationship.

Our subject here will only deal with the vented direct radiator (or bass reflex) enclosure for FORCE loudspeakers and the effects on the response curves resulting from different enclosure tuning and enclosure volume.

You, as the builder, have control of the two most significant factors in determining the performance of a vented system; the enclosure tuning and enclosure volume. By varying either of these parameters, the bass response characteristics can be tailored to realize a personally desirable sound.

ENCLOSURE DESIGNS

Figure 1 shows the computer generated curves depicting an Electro-Voice FORCE 10 speaker in a 1.4 ft³ enclosure. Curve A represents the predicted bass response with the enclosure tuned to the free air resonance of the speaker (65 Hz) and would be considered a classic B⁴ (Thiele's Alignment No. 5)¹ enclosure.

This tuning produces the flattest curve with the -3 dB level at 65 Hz and a -10 dB level at 52 Hz.

By simply retuning the enclosure to 1/2 octave lower (49 Hz) the response curve B starts rolling off about one octave higher than in curve A and the -3 dB level has shifted to 95 Hz with the -10 dB at 45 Hz. This could be considered an unequalized B⁶ (Thiele's Alignment No. 15) enclosure and the bass would sound a little "thin".

Our third curve (C) in Figure 1 shows the effect of tuning the enclosure 1/2 octave above the free air resonance of 65 Hz or to 98 Hz.

This higher tuning has created a hump of +4.5 dB at 120 Hz as well as shifting the -3 dB level to 85 Hz and -10 dB level to 70 Hz. Aside from sounding like a "boom box", this enclosure would also accentuate any 120 Hz hum in the amplifying system.

The next set of curves (Figure 2) represents the effects on the system response by changing the enclosure volume while maintaining the enclosure tuning of 65 Hz as a reference.

Reducing the enclosure volume by one-half has the same effect on the response curve (Figure 2B) as lowering the enclosure tuning (shown in Figure 1B). The -3 dB level is also at 95 Hz but because of the faster rolloff, the -10 dB level has shifted to 60 Hz.

Doubling the enclosure volume to 2.8 ft³ (Figure 2C), the hump is still apparent but has been reduced to about +1.5 dB. Also, the peak of frequency of the hump has shifted from 120 Hz to 70 Hz and a slight loss in level in the upper bass region has developed. The -3 dB level has shifted to 59 Hz and the -10 dB level to 50 Hz.

With the countless combinations of enclosure volume and tuning, it is obvious that almost any shape response curve can be achieved for a given driver (within the limits of the driver, of course).

Similar curves have been developed for the FORCE 12 and FORCE 15 speakers (Figures 3 through 6), and you will notice that the characteristics of these curves are the same except for frequency shifts and magnitude.

CONSTRUCTION SUGGESTIONS

In the actual construction of the enclosures it is assumed that one has the basic knowledge of woodworking methods. The plans, included, show uncomplicated butt joints for simplicity sake, but the joints can be modified according to the knowledge and expertise of the individual's wood-working skills.

It is most important that the enclosure be as mechanically well built as possible. There should be no rattles or buzzes, and all joints must be airtight. This includes air leaks caused by connector openings. Speakers can't tell the difference between an air leak at a joint and a designed port. The result could be a cabinet that is tuned higher than intended.

Material selection is important from the standpoint of sound quality, the application of the system, the beauty of its finish and, of course, the cost.

For sound quality, the material should have a high density and, in the case of plywood, should be free of any voids that could resonate and color the sound. The ruggedness of the enclosure would depend on the application. For a permanent installation, such as a club or auditorium, particle board or a good grade "chip core" veneer would be suitable. Also, for more appealing wood finish enclosures, select lumber core veneers or even solid wood planks could be used.

Road cabinets, on the other hand, which can be crushed, creased and punctured through abusive handling, require a stronger material such as marine plywood. Added protection for portable enclosures can be provided with edge extrusions, metal corner protectors and front cover panels over the

grilles. Also, the final finish of the cabinet has to be considered. Some of the alternatives are painting, vinyl covering, Formica®, or even natural wood finishes, if desirable.

With the slightly recessed baffle, grilles can be easily fabricated for these enclosures.

If the fabric grilles are to be used, a frame slightly smaller than the baffle area should be assembled of 3/4 inch square material and the grille cloth stretched over and stapled to the frame. The grille cloth should be a very open weave fabric to avoid acoustic loading of the speaker or the vent opening.

The grille assembly can be secured to the baffle with velcro type fasteners for easy access to the speaker.

For portable or road type enclosures, perforated metal grilles can be cut to the baffle size and, using the 3/4 inch frame described above, can be assembled to the baffle with screws. There are, of course, many personal touches that could be considered in building your enclosures and each of them should be given serious thought.

As with any product, serviceability should be kept in mind, and driver accessibility is a must. The enclosure plans are all designed for front mounting of the speakers with our SMH-1 mounting hardware kit, which is available as an accessory.

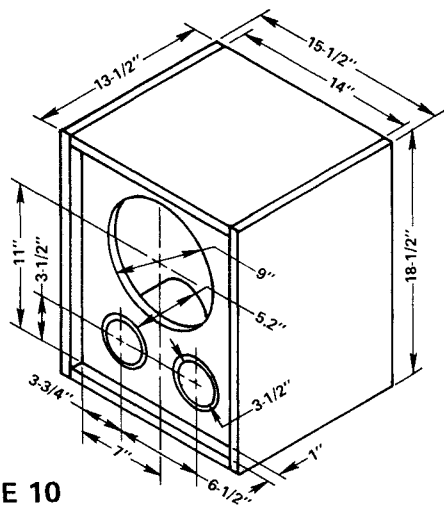
REFERENCE

1. A. N. Thiele, "Loudspeakers in Vented Boxes: Parts I and II." **Journal Audio Engineering Society**, Volume 19, PP. 382-392, (1971 May); PP. 471-483 (1971 June).

The chart below shows the venting required for each of the enclosures mentioned in this addition

	FORCE® 10					FORCE® 12					FORCE® 15				
V _B (Encl. Vol. in ft ³)	1.4*	1.4	1.4	.7	2.8	3	3*	3	1.5	6	5*	5	5	2.5	10
f _B (Encl. Tuned Freq. in Hz)	65	49	98	65	65	55	41	82	55	55	40	30	60	40	40
S _v (Vent Area in Inches ²)	19.2	9.8	31.8	9.6	19.2	19.2	19.2	66.4	15.9	47.5	19.2	19.2	66.4	15.9	66.4
L _v (Duct Length in inches)	5.2	5.3	1.7	6.2	.75	2.1	6.7	2.1	6.2	1.3	2.9	7.9	3.2	7.4	4.4
Vent Diameter (inches)	3½	2½	4½	3½	3½	3½	6½	6½	4½	5½	3½	3½	6½	4½	6½
No. of Vents	2	2	2	1	2	2	2	2	1	2	2	2	2	1	2

*The dimensions on the plans are for the optimum tuning and enclosure size.



FORCE 10

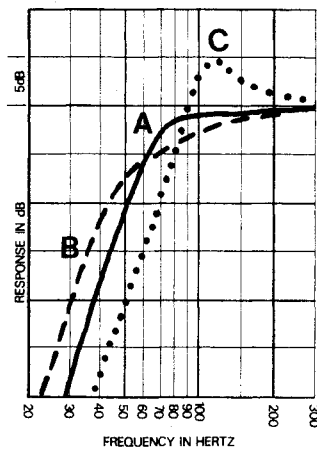


FIGURE 1

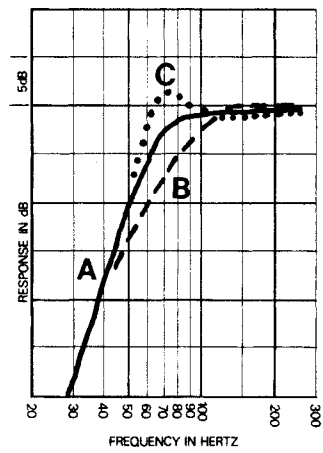
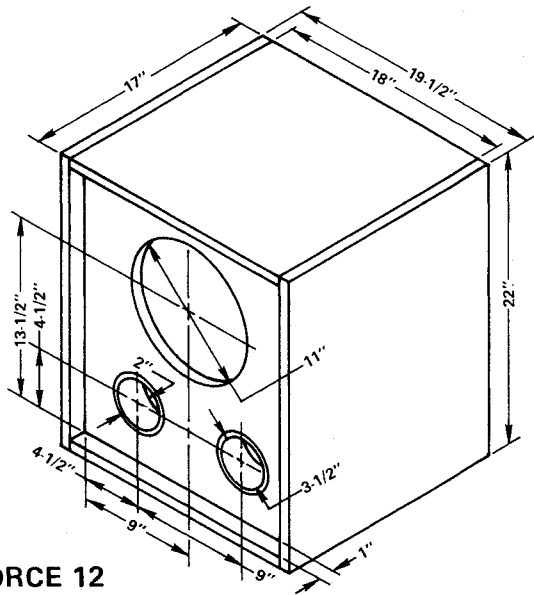


FIGURE 2



FORCE 12

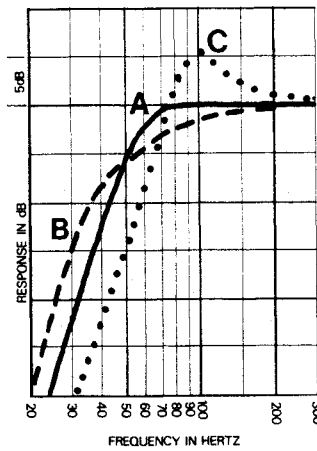


FIGURE 3

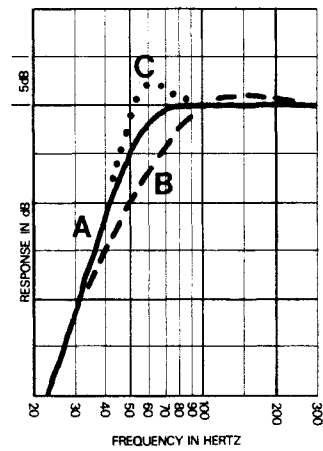
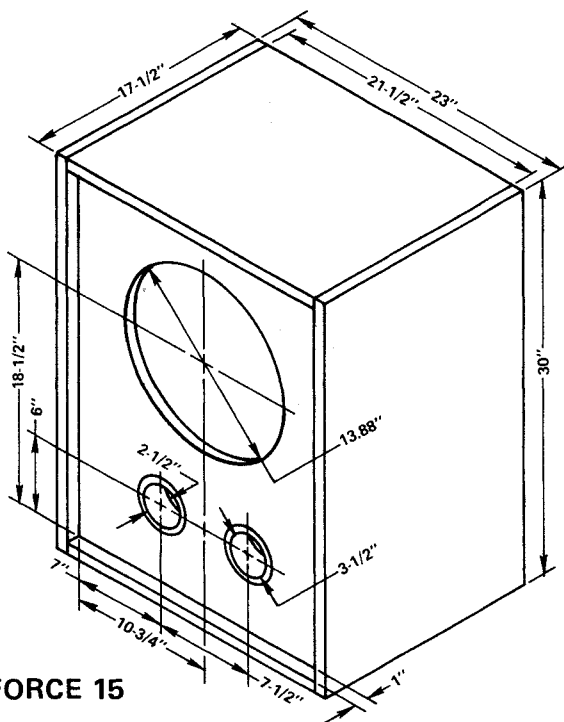


FIGURE 4



FORCE 15

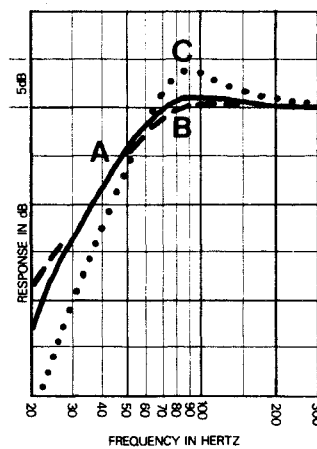


FIGURE 5

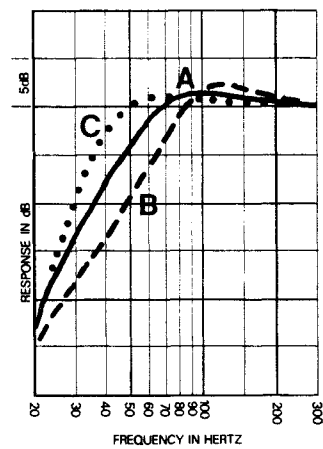


FIGURE 6



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