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21 CUSTOM SPEAKER ENCLOSURE PROJECTS YOU CAN BUILD

A step-by-step guide to innovative, efficient audio speakers, with complete design and construction details!

BY DAVID B. WEEMS

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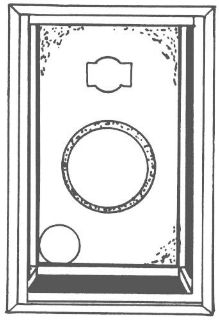


Audio fans often debate about how much money you can save by building your own speaker system. Some manufacturers, wanting complete control over the use of their products, discourage home speaker builders. One reason is they fear that sloppily made enclosures will degrade the sound of their speakers. But there are other, more practical, reasons why certain companies and some audio salesmen try to steer you into a factory-made system. Interestingly, other manufacturers, with equally prestigious names to uphold, gladly furnish information and encouragement to the amateur speaker builder. Fortunately the number of companies in the latter category seems to be growing at a significant rate.

There is no easy answer to the question of how much you can save; much depends on the materials you choose. For example, you can probably buy a good number of factory-made systems in which the figure you pay for the cabinet will be lower than what you must shell out for the enclosure materials of the Omni-Hex. But if you do a careful job on the Omni-Hex, you'll have a fine piece of furniture instead of a mass-produced carbon copy of every other stereo speaker on your block.

Looking through the projects in this book, you will notice that their appearance varies from conventional looking enclosures to some uncommon shapes. In size, these projects vary from mini-enclosures with a cubic volume of one-sixth cubic foot that can fit onto the smallest bookshelf up to an 8 cubic foot floor model. Electrically the spread is just as great, from simple speaker-in-a-box projects to others with crossover networks of varying complexity and up to six or seven drivers.

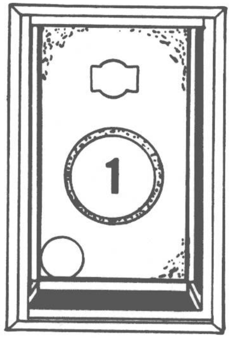
These projects were chosen because they pleased a panel of listeners. But more than that, listeners were used as guides in making final decisions in project design. For example, in a few projects changing a crossover network component from the theoretically correct value to another value produced better sound, at least in the opinion of several careful listeners. In such a project the change was made. So if you calculate the value of a choke and find it to be different from that specified in the materials list, don't be surprised. If you like to do your own calculations and believe in theory above everything, follow your computer. But remember this, it's an imperfect world—especially where loudspeakers are concerned.

At the beginning of the description of each project you'll find a quick summary of what to expect from that project, both from its difficulty of construction and its sound. Words mean different things to different people, so trying to describe sound character is a tricky business. But if you have definite tastes in the kind of sound you like, the comments for each project should help you choose a speaker system whose performance will please you.

So choose yourself a project and get started. Do a good job, but don't forget to have fun while you're doing it. That's really what this book is all about.

David B. Weems

Enclosures



Engineers sometimes measure the sound of a new speaker while suspending the bare speaker in mid-air. One company even publishes the frequency response curves of such tests. In these curves the response breaks sharply downward below 1000 Hz, showing that a speaker without a box is as helpless as a fish out of water. But when the same speakers are installed in a properly designed enclosure, their response is flat to 100 Hz and within 2 or 3 dB to 50 Hz.

A careful inspection of the two sets of test results show that a box can enable a speaker to deliver 100 times greater sound intensity at 100 Hz than it can produce without the box. Why is a box so important? Does the box produce the extra low frequency power?

Unlike musical instruments, a speaker is a reproducer of sound. It should produce no sound of its own. And a box that makes sound is a bad enclosure. Instead, its function is to block the out of phase sound from the back of the cone so it can't cancel the sound out front. Because low frequency sound waves are naturally omnidirectional, the bass suffers most in an unbaffled speaker. Some enclosures, ported boxes for example, reverse the phase of the backwave and use it to reinforce the bass. But the box itself is silent.

Tweeters usually have an enclosed back, so they need no enclosure except for appearance and proper placement. Many midrange speakers, too, have a plastic shell over the back of the frame, filled with damping material. If you use an open-back speaker for a mid-range driver and install it in the same box with a *woofer*, you must put a sub-enclosure over the back of the mid-range speaker. Failure to isolate a mid-range driver leaves it at the mercy of air pressure changes that can be great enough to produce increased

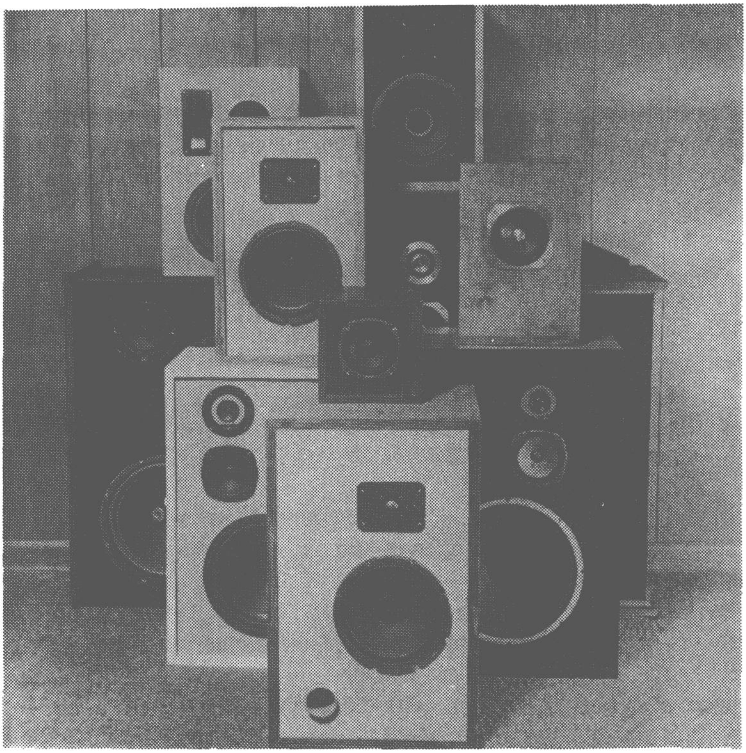


Fig. 1-1. Some of the projects described in this book.

distortion and even damage. Each driver needs some kind of enclosure, and the size of the enclosure is related to the cone area of the driver as well as the lowest frequency of sound it must reproduce. Thus tweeters can have flat closed backs, an insignificant cubic volume, but a 15″ woofer requires a box of several cubic feet.

There was a time when almost all speaker enclosures looked alike, but no more. A walk through an audio showroom will reveal an almost endless variety of shapes and sizes of speakers, from the simple to the extreme (Fig. 1-1). Why this diversity? Probably because some manufacturers have recognized that many customers want more than just good sound. In some cases they want a speaker that has great visual interest. Or, like the Pharaoh who built his pyramids upside down, they want something unusual.

DIFFERENT TYPES OF ENCLOSURES

Certain rules should be followed in building a speaker system but almost everyone compromises, to some degree, between optimum audio and performance and appearance. For example, a sphere would have some theoretical advantages but not many people own globular speakers. The speaker systems described in this book are designed with respect to proven principles, but they are also designed to be practical.

In Fig. 1-2 you can see several obvious variations in shape possible with a six-sided box. The cube, Fig. 1-2A, is considered one of the poorest choices for a speaker box because it has the same internal distance in three directions. Each of these dimensions would favor the same wavelength, a condition that can produce a

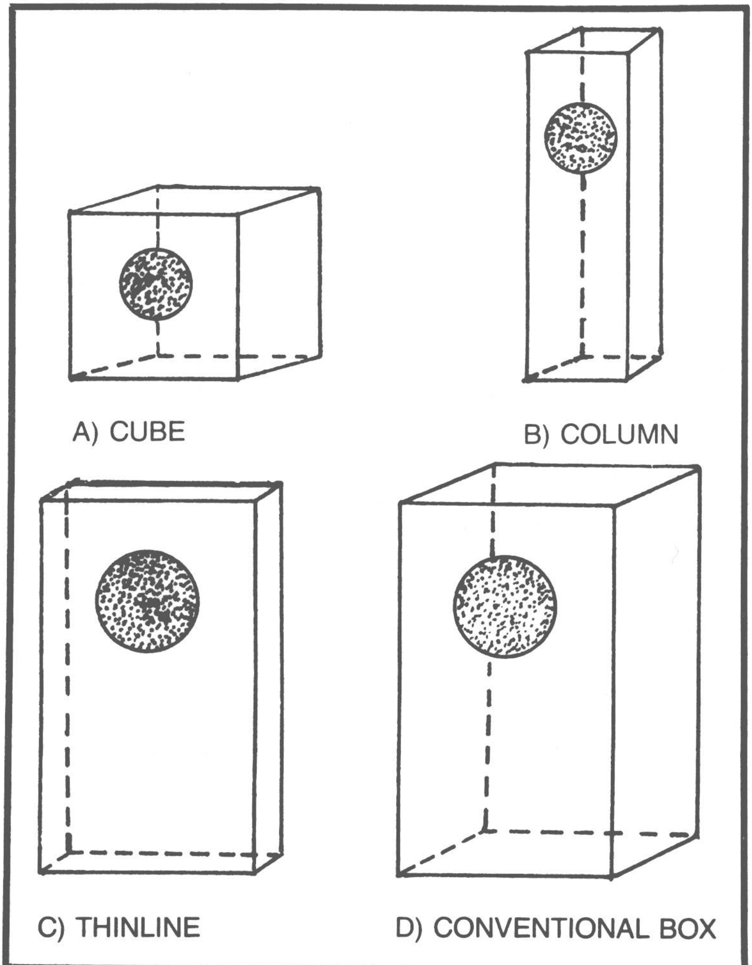


Fig. 1-2. Four possible shapes of six-sided speaker enclosures.

peaky response curve. But later in this book you will see a miniature speaker system with cube-shaped boxes. If the desired cubic volume is very small, a cube may be more desirable than another shape with too little depth behind the speaker.

The second variation, Fig. 1-2B, is prevalent today in column speakers. A simple box with one internal dimension acts like a tuned pipe. That's bad. Such a pipe will produce a frequency response curve with noticeable peaks and valleys. You can stuff the pipe with damping material and modify the roughess, but if you overstuff, you'll kill the bass. Such an enclosure is difficult to debug, so why try? Yes, there is a tower in this book, too. The one used here has been broken into sub-enclosures by a partition, so it doesn't act as a pipe. The tower does have some aural advantages as well as giving a distinctive appearance. Mid-range sound is dispersed more widely from a narrow enclosure than from a wider one, so towers usually have well-dispersed sound unless the mid-range driver is poorly designed or too large.

In some situations it is necessary to use the space saving shallow box, Fig. 1-2C. The nearness of the back wall to the speaker cone aggravates a basic weakness of all simple speaker boxes—reflections. Sound from the rear of the cone travels to the back of the box and is reflected 180 degrees onto the cone again. This reflected sound can travel through the cone, producing peaks at frequencies where it is in phase with the cone and dips at other frequencies. If reflections are serious, the sound will be harsh because of mid-range peaks. Where a shallow box is necessary, it should be filled with damping material. Or if that overdamps the speaker, the space between the speaker and the back should be filled. Where possible, avoid the shallow box. A good rule of thumb is to make the internal depth of the enclousure at least 1½ times that of the speaker itself.

This brings us to the typical speaker box, shown in Fig. 1-2D. While it isn't ideal with its parallel walls and its sharp external corners, it will likely continue as the most popular shape. Here are some dimension ratios that are often used: 5:3:2, 8:5:3 and 14:10:7. Notice that in the first two ratios the dimensions are staggered so that none of them is an even multiple of any other. The third ratio is based on a difference in dimensions equal to the square root of two, which produces a long dimension that is twice as great as the shortest.

If you like to experiment with different shapes of enclosures, Figs. 1-3A through 1-3D show some of the shapes recommended for their acoustical advantages. Several years ago the English speaker authority, G. A. Briggs, rated several shapes on a scale of 10. His ratings of the six-sided boxes shown in Fig. 1-2 were as follows: cube, 3; thinline, 5; and typical box, 7. But he rated hexagonal enclosures at 9 and triangular shapes at a full 10. The reason for the high rating of the triangular shape is that there are no parallel walls and the backwave from the speaker is broken up rather than reflected back to the cone.

Externally the shape is less desirable than that of the rectangular truncated pyramid mounted on a box, Fig. 1-3B. The hexagonal shape offers the same advantages and disadvantages as the rectangular truncated pyramid on a box, good external design but with the opposite wall parallel to the speaker board. That leaves the pentagonal shape which would seem to give the best of both worlds—no internal parallel surfaces and no sharp external corners. The speaker could be installed on one of the sides, or on a sloping top board, as shown. Mr. Alexander Mench, of Fort Worth, Texas, reports good performance from a pentagon. Theoretically, at least,

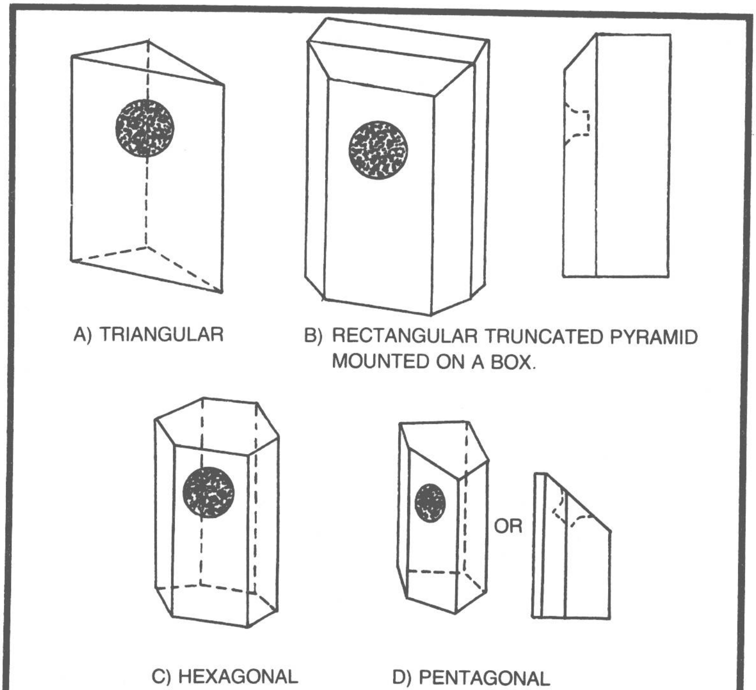


Fig. 1-3. Some rarely used shapes of loudspeaker enclosures that offer good performance.

the pentagon is an attractive choice among the enclosure shapes available to the speaker builder.

CONSTRUCTION RULES

If you decide to build one of the speaker systems in this book but want to change the shape of the box, make sure the internal volume is about the same as that specified in the drawings for the project. You can also make other kinds of changes to fit your tools and materials. Just observe the construction rules that follow.

Rule 1: Make a Rattle-Free Box

The best way to avoid rattles is to do a good job of gluing the joints. Experienced carpenters try to use just enough glue to hold so it won't be smeared onto raw wood and spoil the appearance. That technique will work well enough for most furniture pieces, but it can cause problems in speaker boxes. Unless the wood members are cut to close tolerances, the skimpy use of glue can leave air leaks, not to mention rattles. To avoid the problem of excess glue creeping onto the exterior surface, you can cover the areas near the joint with masking tape. Also, you can put a heavier coating of glue near the interior side of the joint.

If you must make one panel removable, use carefully installed foam weather stripping to seal the box and prevent rattles. Several boxes in this book are shown with weather strip sealing because it was necessary to make changes in crossover or box design after initial testing. The largest reflex is an example. To tune the enclosure, the front panel had to be removed. For a builder, who is following a set of plans, the front panel can be installed with silicone rubber glue. Notice that such a box would be built with conventional wood glued joints except for the last panel, which would be installed with silicone rubber glue.

Rule 2: Make The Box Airtight

Even the smallest gap between joints can cause air noises that mar performance. If the air leak is significant, it can unload the woofer, increasing distortion and limiting its power handling ability. To insure against leaks, all joints made with wood glue should be caulked after the glue sets. Latex caulk is an economical choice for wood joints and has good lasting qualities when used in a speaker box. Silicone rubber is an excellent caulk, but it costs about four or five times as much as the latex caulk. You should choose the silicone rubber to seal speakers to the box. Latex caulk can cause corrosion on bare metal and doesn't adhere very well to painted metal. If you are building a one-piece box, with no removable panels, you can start the box by assembling the sides, top, bottom and the speaker board. Caulk all inner joints before installing the back. Then reach through the speaker holes to caulk the joints around the back.

Apply the caulking material with a gun; then smear it into the joint with a rounded tool. Clean popsicle sticks make good spreading tools.

Rule 3: Choose Quality Material

The most common speaker box material is ¾″ plywood or particle board. Panel thickness should be chosen to match enclosure size. For example, a box with a cubic volume of, say, ¼ of a cubic foot can be built from ½″ plywood or particle board. Such a box will have individual panels small enough that ½″ material will provide adequate stiffness. Unless the panels are unusually narrow, as in a tower, all enclosures for woofers with a diameter of 8″ or greater should be built from ¾″ material. Large panels should be braced for adequate stiffness.

If you use plywood, choose a good grade. Hardwood plywood, such as birch or walnut, is usually well made, but cheap grades of fir plywood will have great voids and poorly glued layers. Voids weaken the panel and loose layers can cause rattles. If you must use fir, ask for "AB" grade of interior plywood. If your plywood has voids, enlarge the enclosure by ½″ each dimension and line the walls with ½″ particle board.

Some of the enclosures in this book show solid pine exterior surfaces. Solid pine is adequate for small boxes or, if lined with particle board, for large enclosures. Unfortunately some of the pine that is sold now as "kiln dried" evidently was rushed through the kiln. This relatively unseasoned wood will warp badly unless you assemble the parts the same day you cut them out. Where you must join more than one board to get the necessary width, as in the largest project, you may find that the boards will shrink as they season, pulling the joints apart. Ideally, such pine should be held in a dry place for several months. If you can find well seasoned wood, pine is an attractive choice for exterior work.

Particle board is especially desirable for good sound. It is dense and has no loose parts or voids. Choose an industrial grade. You can identify the right grade by examining the particle size and the edges of the board. The best particle board for speaker box construction has small particles and smooth edges. Avoid board that is crumbly or flaky.

To some extent your choice of material will dictate your construction technique. For example, if you buy a good grade of ¾″ birch plywood, you will probably want to make beveled joints at the corners to hide the end grain. Here you must be careful in your use of glue to avoid forcing an excessive amount of glue out to the joint and onto the unfinished exterior. Another problem is to clamp the parts together until the glue sets. The simplest way to do that is to wrap something around the box shell to hold the parts together. Adjustable straps are good, but you can use rope, old bicycle tubes, or even tape to apply some degree of pressure to the joints. This kind of joint is likely to be weak, so it's a good idea to add internal glue blocks for reinforcement, especially if the enclosure is larger than 1 cubic foot. Just cut the blocks from ¾″ stock and glue them into each corner, as shown in Fig. 1-4. The blocks can be clamped or screwed into place so that some pressure will be applied while the glue sets.

If you have a power saw, you can make a rabbet joint that will show very little plywood end grain. You can use a set of dado blades to make the cut in a single pass through the saw, but dado blades sometimes cause splintering. A safer method is to use your combination saw blade to remove the amount of material desired. This will require two passes over the saw, one with the material on the table and a second pass with the panel on edge. Always make some practice cuts on waste material to check the setting of your saw blade.

A variation of the rabbet joint is a joint with a solid wood filler at the corner. I call it the "Porter joint" because it was first demonstrated to me by a cabinet maker named Amos Porter. To make it, you set your saw blade to make a cut ½″ deep and set the fence at ½″ from the opposite side of the blade. When you run the panel through the saw twice, first flat and then on edge, you will remove a ½″ × ½″ strip of material. The joining panel is left full thickness. When it sets in the ½″ × ½″ groove, a notch, measuring ¼″ × ¼″, is left at the corner. You can fill the notch with a strip of ¼″ quarter round or cut a piece of ¼″ × ¼″ wood and glue it in the notch. It's a good idea to gently round off the sharp edge to give a smoother corner and to prevent splintering. This kind of joint, shown in Fig. 1-4, can take considerable punishment because of the strip of solid wood that protects the edges of the plywood veneer.

For particle board enclosures the ordinary butt joint is the sensible choice. Use plenty of glue and 6-penny finishing nails. You can sand off any irregularities after the basic box is completed. Then