Electro-Voice®

TECHNICAL BULLETIN #10A

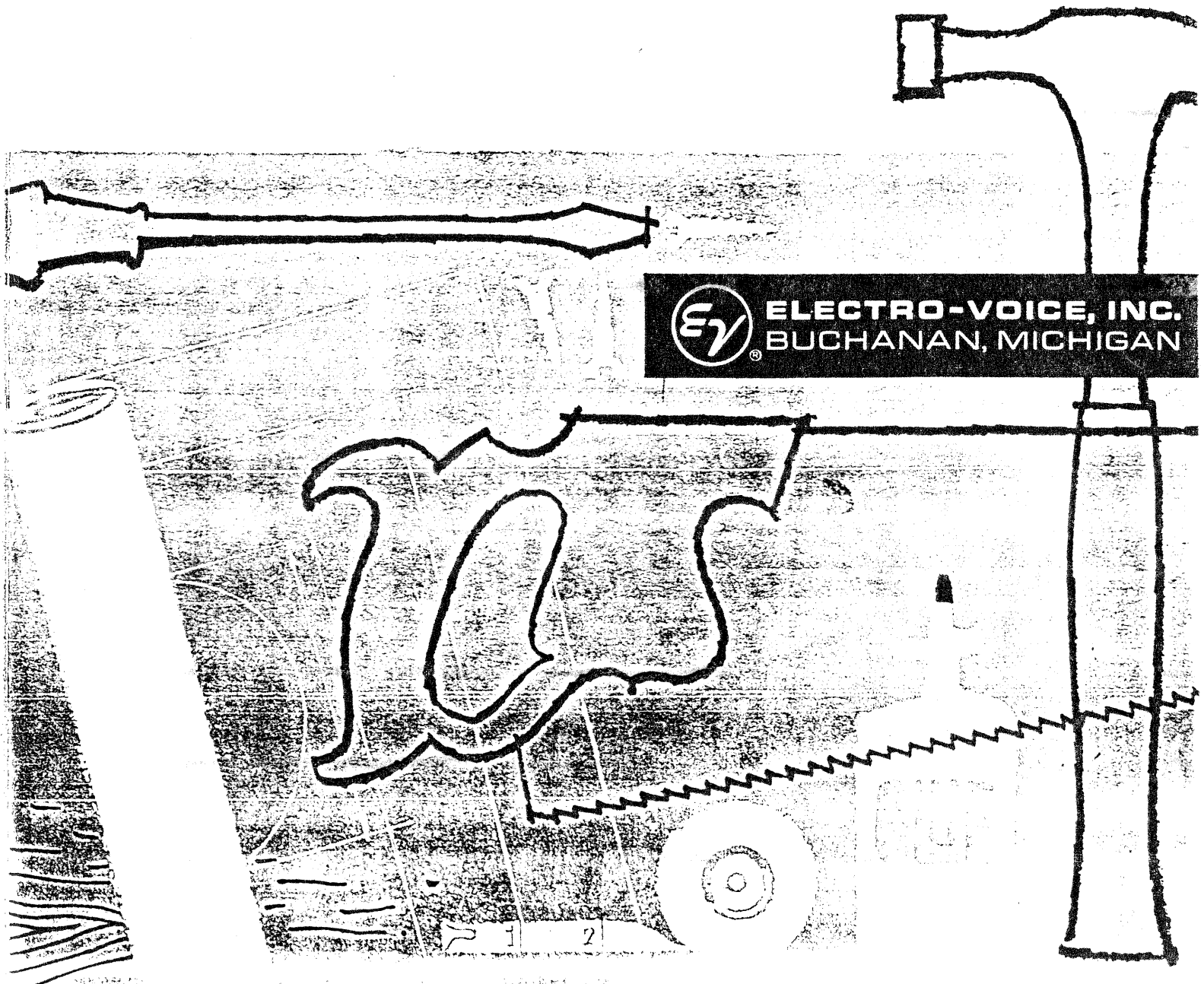
Design and Construction

OF

BASS REFLEX ENCLOSURES

FILE COPY

FOR ELECTRO-VOICE • WOLVERINE AND MICHIGAN LOUDSPEAKERS



ELECTRO-VOICE, INC.
BUCHANAN, MICHIGAN

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INTRODUCTION

No high fidelity loudspeaker is complete until it has been mounted in a satisfactory enclosure. An enclosure is necessary to prevent the loudspeaker's rear radiation from cancelling out the energy from the front of the cone, since the sound waves from the two sides of the cone will be 180-degrees out of phase. In addition, a properly designed enclosure can actually augment or improve the sound produced by a loudspeaker, particularly at low frequencies.

Since the inception of high fidelity, the building of loudspeaker enclosures by the audiophile and amateur woodworker has been extremely popular. The following information is provided by Electro-Voice as an aid to those who wish to take advantage of the fine performance and appreciable cost savings which can be realized from a home-constructed enclosure.

ENCLOSURE TYPES

Most of the loudspeakers produced by Electro-Voice are designed particularly for bass reflex and folded horn enclosures. These two types of enclosures enhance the efficiency of the loudspeaker, produce less distortion, and extend flat response down to and even below the loudspeaker's cone resonance.

Good horn enclosures provide magnificent bass response, but they are generally expensive, difficult to design and construct, and very large.

Another type of enclosure in which Electro-Voice speakers work well is the infinite baffle. This is simply an enclosed volume of air behind the speaker which serves to keep the sound wave from the back of the speaker cone from interfering with and cancelling the front wave. Such an enclosure usually requires a volume of 20 to 35 cubic feet, and ready-made enclosures, such as closets, are often used. However, because closet doors are seldom found in locations which afford suitable listening areas, infinite baffles are not widely used in home high fidelity installations.

The compact or "bookshelf" system poses another problem entirely. In order to achieve good bass response in a small enclosure, certain compromises in woofer design must be made. Because the matching of components to a small box is rather crucial, Electro-Voice does not offer these components and enclosures separately. Among the many finished systems in the E-V line are several compact systems offering performance which belies their small size. However, an attempt to use standard Electro-Voice, Wolverine, or Michigan speakers in these small enclosures will result in degradation of the fine bass performance of which these speakers are capable. Generally speaking, eight-inch speakers require a minimum enclosure volume of two cubic feet, twelve-inch speakers require at least four cubic feet, and fifteen-inch speakers require eight cubic feet or more.

The simplest and most flexible enclosure for construction in a home workshop is the bass reflex type. This enclosure can be built in many different sizes, has flexibility of shape, and is especially useful in adapting bookshelves and other available spaces to speaker enclosures. Aside from ease of construction and versatility, bass reflex design offers excellent performance, even with enclosures of moderate size.

PROPORTIONS

Ideally, the proportions of the bass reflex enclosure should not be extreme. Particularly to be avoided are long, narrow enclosures which tend to exhibit an "organ pipe" resonance at particular frequencies. It is recommended that the width of the enclosure be approximately two-thirds the height and depth approximately one-third the height. This is illustrated in Figure 1. Considerable variation from this can be tolerated, but the shortest dimension should be no less than one-third that of the longest.

VOLUME, PORT AND DUCT DIMENSIONS

Generally, the largest size possible should be used for the cabinet volume, although no qualitative difference will be observed beyond approximately 30 cubic feet. The minimum volume which should be used when housing a twelve-inch speaker is approximately four cubic feet, and the minimum volume for an eight-inch speaker is two cubic feet. Once the dimensions and volume of the enclosure have been determined, and the loudspeaker has been chosen, it is possible to arrive at the final consideration in the design of a bass reflex enclosure. This is the port, or extra cutout on the baffle board. It is this port which makes possible the advantages of the bass reflex enclosure; its size must, therefore, be selected with care if the enclosure is to function properly. Ideally, the port should have an area equal to the effective area of the speaker cone. However, as enclosure volume is reduced, the port area must also be reduced in order to maintain the proper match between speaker and enclosure resonance. The addition of a duct or "tunnel" behind the port allows a larger port area for a given enclosure volume. This results in greater radiation efficiency. The chart permits the proper determination of the port area and duct length, once the enclosure volume and loudspeaker have been selected. Normally the port cutout is rectangular and is located directly below the loudspeaker opening. The length-to-width ratio of the port has an effect on the resonance of the enclosure; the length should be no more than four times the width. Within this restriction, the hole may be of any shape, including circular.

CONSTRUCTION NOTES

1. Use ¼-inch or thicker plywood. Solid lumber is likely to warp and cause difficulties later. The plywood should have tight cores and no less than five plies. The enclosure must be rigidly constructed with adequate bracing and liberal application of glue blocks. All panels except the removable one for speaker access should be glued and screwed.
2. The loudspeaker mounting hole should be off-center if possible to assist in the prevention of standing waves on the cabinet interior.
3. The port should be close to the speaker cone opening if possible, although exact placement on the front panel is not critical.
4. The duct for square or rectangular ports should be constructed of ¼-inch or thicker plywood, using corner blocks, if necesary, for rigidity. The duct for a round port may be constructed of materials such as linoleum or even heavy cardboard, as long as the finished duct is sturdy and vibration-free. (See Figure 2.)
5. If separate tweeter or midrange drivers are to be added, proper cutouts should be provided. Generally these should be located near the top of the enclosure (nearest ear level when seated in normal listening position). For maximum horizontal dispersion from Electro-Voice diffraction horns, they should be oriented with the long axis vertical. (See Figure 3.) If the high-frequency drivers are not to be added until a later date, the cutouts should be covered on the inside of the enclosure by a removable panel of ¼-inch plywood.
6. Line the interior surfaces, with the exception of the speaker panel, with a one- or two-inch thickness of acoustically absorbent material. Most high fidelity equipment dealers stock fiberglass or some similar material for this purpose. This may be applied with tacks or staples.
7. The loudspeaker components should be mounted to the front panel by means of carriage or fin bolts. An alternative would be the use of ordinary machine screws and tee nuts. These are available through local hardware dealers.

SPECIFIC ELECTRO-VOICE DESIGNED ENCLOSURES

For the finest possible performance, when exact dimensions are not a factor in the choice of an enclosure, you may wish to build one of the Electro-Voice factory-designed enclosures. Complete blueprints are available on several enclosures that Electro-Voice has marketed over the years. (See Table 2.)

INSTRUCTIONS FOR USING BASS REFLEX DESIGN CHART

Determine the volume of your enclosure, using its inside dimensions. If possible, pick a volume from the suggested enclosure volume range for your speaker shown in Table 1.

1. Find this volume on the "volume in cubic inches" scale on the chart. Draw a line horizontally from this point across the chart.
2. Find the point where the diagonal straight line representing your speaker crosses the horizontal line from Step 1.
3. From this point, drop a line vertically through the curved lines on the lower half of the graph.
4. Note the suggested port area range for your speaker on Table 1.
5. Find the point where the vertical line from Step 3 crosses the first curved line representing a port area within the recommended range found in Step 4. With an extremely small enclosure, it is possible that none of the recommended areas will be intersected. In this case, start with the first area line which is crossed. The fact that the largest possible port area is too small indicates that the enclosure is too small for optimum bass reflex operation with the selected speaker.
6. From this point, draw a horizontal line to the "duct length in inches" scale on the right side of the graph and note the duct length indicated.
7. Now find the point where the chosen area curved line intersects the "duct clearance" line.
8. Draw a horizontal line from this point to the inches scale at the right side of the chart. Note the indicated figure in inches. This figure represents the minimum clearance which must be maintained between the rear of the duct and the back panel of the enclosure.

9. Add the "duct length" and "duct clearance" determined in Steps 6 and 8. This sum must be less than or equal of the depth of the enclosure. For purpose of computation, the depth of the enclosure should include the thickness of the front panel but not the rear panel. (This is necessary because the duct length includes the thickness of the front panel.)

10. If the sum of the duct length and duct clearance is not greater than the enclosure depth, you have arrived at the most favorable combination of port and duct dimensions for your speaker and enclosure.

11. If on the other hand, the computed duct length and duct clearance total exceeds the enclosure depth, it is necessary to recalculate these factors beginning with Step 5 and choosing the next smaller port area.

12. Repeat this procedure if necesaary, until a usable port area and duct length combination is found.

At this point, you have acquired some appreciation of the complex science of electro-acoustic design.

The following typical cases illustrate proper use of the attached Bass Reflex Design Chart.

Figure 1
Recommended proportions

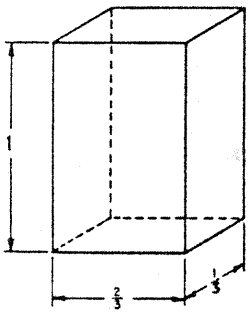


Figure 2
Construction of typical duct

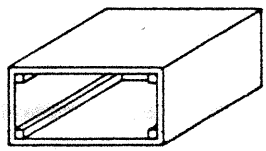
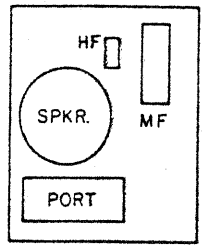


Figure 3
Typical placement of panel cutouts



EXAMPLE 1

Determine port and duct dimensions for an SP12B in an enclosure measuring 30" high by 20" wide by 17" deep outside.

If ¾" plywood is used for the walls, the volume inside is 28½" by 18½" by 15½", or 8174 cubic inches. This volume is within the suggested range for the SP12B. Now locate 8174 (about 8200) on the "volume in inches" scale on the right side of the chart. Draw a horizontal line across the chart from this point. Find the point where the diagonal SP12B line crosses the horizontal line. From this point, draw a vertical line downward through the curved lines on the bottom half of the graph. Note from Table 1 that the largest suggested port area for the SP12B is 100 square inches. Find the point where the vertical straight line just drawn crosses the curved line marked A = 100. Draw a horizontal line from this point to the "duct length in inches" scale on the right side of the chart and note that it indicates approximately 14 inches. Now find the point where the A 100 curved line crosses the "duct clearance" line. Draw a horizontal line from this point to the inches scale at the right side of the chart. Duct clearance is approximately 5¾". The sum of the duct length and duct clearance in this case is 14" plus 5¾" or 19¾". However, this length is greater than the depth of the enclosure minus the thickness of the back panel (17" minus ¾" = 16¼"). If it is refigured using the A = 80 line, the duct length is 11" and the duct clearance is 5½". Now the total distance is just equal to the enclosure depth of 16¼". This combination could possibly be used, but in order to allow a margin for error, refigure it once more using a port area of 64 square inches. The lines for this computation are shown on the graph in dotted form. The indicated duct length is now 7½" and the duct clearance is 4½". The needed depth in this case is 12" which is well within the available 16¼".

EXAMPLE 2

Determine port and duct dimensions for an SP12 speaker in a cabinet 12" x 18" x 21" outside.

The enclosure internal volume is 10½" by 16½" by 19½" or approximately 3400 cubic inches. Using the previous procedure, the largest possible combination of port and duct is a port area of only 16 square inches and a duct length of 8". This will severely restrict low-frequency output, but it is the best possible for the SP12 in this particular enclosure.

EXAMPLE 3

Determine an enclosure for a 12TRXB speaker, with no space restrictions.

Size is no problem this time, so the largest suggested enclosure volume for the 12TRXB is taken from Figure 2 (15,000 cubic inches). From the intersection of the 15,000 cubic inch line and the 12TRXB line, once again drop a vertical line through the lower portion of the graph. Using the A = 100 line, we determine a duct length of 3-3/8". However, follow the vertical line further down for a moment. You will notice a broken line drawn horizontally at a duct length of .75, or ¾". In effect, the hole cut in the front panel of the enclosure creates a duct ¾" long! Thus, you could cut a port with an area of approximately 70 square inches and not have to add any duct inside the box at all. Eliminating the duct is a good way to simplify construction as long as the port area remains in the recommended range for good acoustical radiation.

CLOSING COMMENTS

Your bass reflex enclosure, when properly designed, constructed, and equipped with quality Electro-Voice drivers, will be capable of very satisfying performance. As with any project of this type, the more care taken in design and assembly, the more perfect will be the result. Your local high fidelity dealer will be able to offer valuable advice on the selection and installation of your loudspeaker components, and your lumber dealer or cabinet maker will be able to answer any questions you may have regarding enclosure construction techniques.

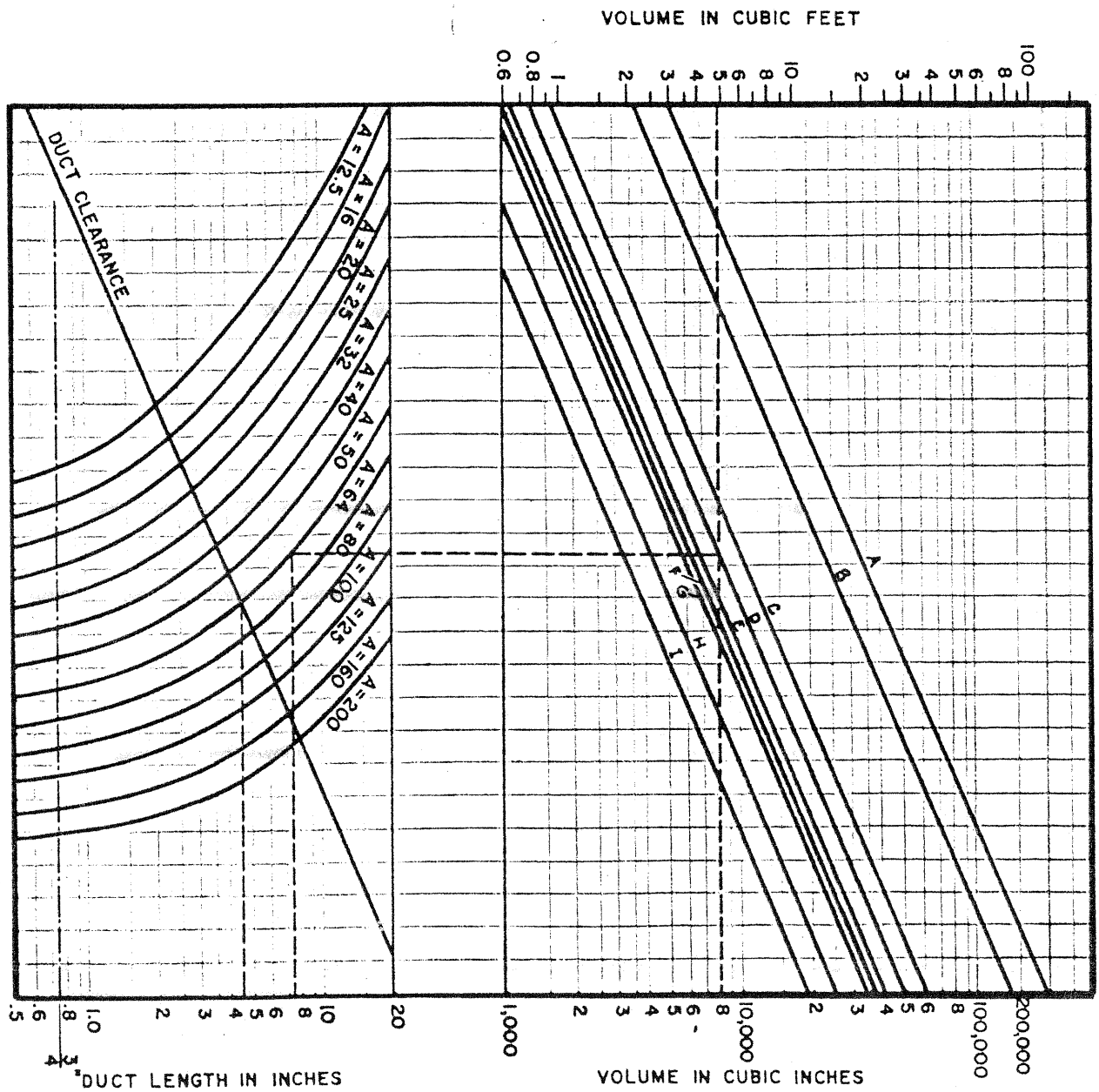


TABLE 1 — BASIC DESIGN DATA

SPEAKER MODEL	CHART LINE	SUGGESTED ENCLOSURE VOLUME (cubic inches)	SUGGESTED PORT AREA (square inches)
SP8B	G	1,500 – 3,000	16 – 50
SP12B, 12TRXB	D	6,000 – 12,000	50 – 100
SP12, 12TRX	C	7,500 – 15,000	50 – 100
SP15B, 15TRXB	B	19,000 – 38,000	64 – 160
SP15, 15TRX	A	19,000 – 38,000	64 – 160
15 TRX Mark II	C	10,000 – 20,000	64 – 160
SRO/12	F	4,500 – 9,000	40 – 100
SRO/15	G	7,500 – 15,000	64 – 160
MC8	H	2,100 – 4,200	16 – 50
LS8	I	1,300 – 2,600	16 – 50
LT8	H	1,700 – 3,400	16 – 50
LS12A, MC12	G	5,500 – 11,000	50 – 100
LT12, MT12	E	5,500 – 11,000	50 – 100
LS15, LT15	D	10,000 – 20,000	64 – 160

TABLE 2 — ENCLOSURE PLANS AVAILABLE FROM ELECTRO-VOICE

Patrician 800*	Four-way System using 30-inch woofer	$2.00
Regency	Fifteen-inch Enclosure	2.00
Aristocrat KD6A	Twelve-inch Corner Enclosure	2.00
Marquis KD9A	Twelve-inch Enclosure	2.00

*Specify Contemporary or Traditional Styling

HIGH FREQUENCY BUILDING BLOCKS

E-V full-range loudspeakers respond to all frequencies in the audible spectrum. However, it is difficult for a single speaker to respond equally well at all frequencies. The addition of separate high-frequency and midrange reproducers and their associated crossover networks is recommended for the finest reproduction. This modification may be accomplished easily through the use of exclusive E-V Building Block Kits which contain matched sets of components complete with wiring harness and instructions. Highly developed driver units with uniform response characteristics work through diffraction horns to give wider polar dispersion. The proper electrical crossover for each driver assembly is included along with level control. Without obsoleting any existing components, you can use the proper Electro-Voice Building Block Kit to add exciting new listening pleasure to your system.

STEP 1 Basic Full-Range System	STEP 2 To complete a two-way system, add the VHF Driver	STEP 3 To complete a three-way system, add the midrange driver
MC8 LS8 MC12 LS12A LS15	HF1	MF1
SP12 SP15 SP8B SP12B SP15B	T35 (BB1)	T25A 8HD (BB4)
12TRX 15TRX	TRX speakers are provided with VHF driver	
12TRXB 15TRXB	TRXB speakers are provided with VHF driver	T25A–8HD (BB4) + additional X36