$1.00

ALTEC®

SPEAKER ENCLOSURES

Their Design and Use

INTRODUCTION

The loudspeaker enclosure design criteria set forth in this brochure is based on accepted acoustical practices and will provide the user with the finest listening pleasure when used with Altec High Efficiency Loudspeaker Components.

The increasing demand for component high fidelity home music systems has focused attention on loudspeaker enclosures. The enclosure is designed both for appearance and as a component of an acoustical system. A properly designed cabinet, however, cannot make a poorly designed speaker operate satisfactorily, nor can a well designed speaker perform efficiently when housed in an inferior enclosure. The speaker and the enclosure must be of good design and work together as a unit. When this is accomplished, response of the system is uniform and the efficiency is good down to the very low bass, and up to or beyond the highest frequency the ear can hear.

The prime reason for an enclosure or baffle is to separate the sound radiated from the rear of a speaker diaphragm or cone so that it does not cancel the radiation generated by the front of the cone. A baffle, then, is a separator that increases the distance between the sources of front and back of the diaphragm to such dimensions that the wave length of the lowest useful frequency is small in comparison to the distance of separation.

TYPES OF ENCLOSURES

A large speaker of excellent quality is better than a small speaker and conversely, it can be stated that a large enclosure of good design is better than a small enclosure. Before any discussion of enclosures, however, one must understand the basic differences among the four major categories, which are as follows:

1. Infinite Baffles - The prime example of an infinite baffle is where a speaker is mounted through a wall with the front of the diaphragm radiating into the listening room and the rear of the diaphragm radiating into another room separated by the wall.

   This type of enclosure is generally not feasible in home music installations and therefore, the current example of an infinite baffle is a completely enclosed box of suitable size.

2. Bass Reflex Enclosures - A bass reflex enclosure consists of an enclosed area with a port opening sized to match the acoustical resonance of the loudspeaker with the enclosed mass of air. This type of enclosure properly designed and constructed has a tendency to give the listener a feeling of a rise of low-frequency response, which is desirable for the best balance in reproduction of the overall frequency spectrum.

3. Horn Enclosures - Horn enclosures involve the use of a horn to couple the radiated energy of the loudspeaker to the air. This type of enclosure, however, because of the physical dimensions of low frequency signals, which by their very nature are long (over six feet), is usually folded to conserve space and in so doing creates phase differences most undesirable between the high and low frequency responses. It is questionable whether a folded enclosure has any of the qualities often prescribed to it.

4. Combination Enclosure - Combinations of the bass reflex and horn enclosures offer proven superior quality in sound reproduction. The advantages of the extended bass response of the bass reflex enclosure, coupled to a short, radiating exponentially formed front loaded horn without folds, further extends the low bass range. One of the best known combination speaker systems is Altec's "The Voice of the Theatre"® line in which the enclosure together with a direct radiating high-frequency horn is featured. (See Figure 1.)

All of the above enclosures will perform satisfactorily, within limits, provided good design procedures are carefully followed and one's expectations do not exceed the limitations. The advantages and disadvantages of each type of enclosure is discussed in the following paragraphs, followed by construction and mounting dimensions for Altec Lansing loudspeakers and enclosures.

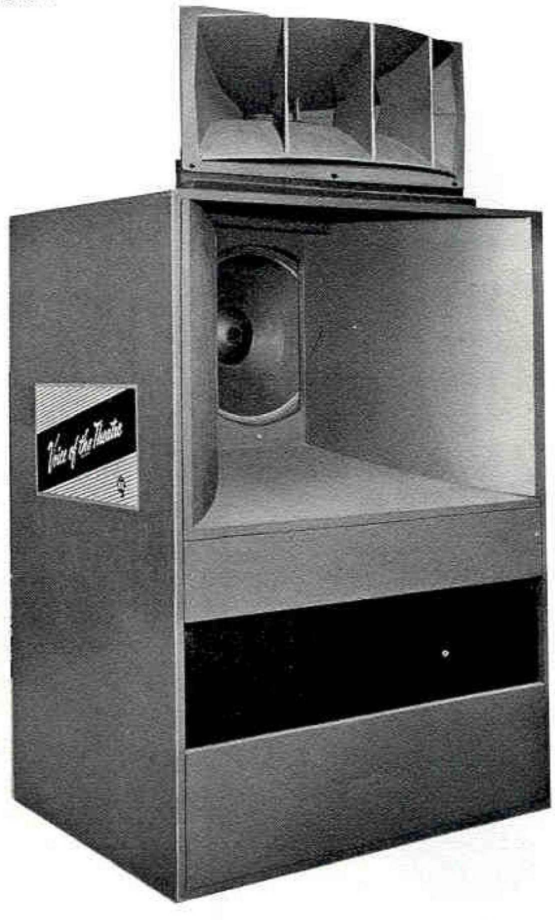


Figure 1. A7-500 "The Voice of the Theatre"® Speaker System

INFINITE BAFFLES

An infinite baffle in its original concept is a rigid wall of great extent, through which the speaker is mounted. Its purpose is to prevent the wave from the rear side of the diaphragm from "flowing" around the speaker and canceling the front wave. It would be at least 55 feet square, and therefore, impractical for home use. Obviously, much less bulky means must be used to prevent cancellation of the front wave by the back wave.

A natural trend of thought would be to fold the baffle into a large box that totally encloses the rear radiation. However, the volume of air that is entrapped in such a box constitutes an added stiffness to the speaker cone suspension system and this stiffness must be properly correlated with the suspension system to avoid a highly restricted bass response. A properly designed infinite baffle of this type is, likewise, too large for average home usage.

In a low compliance speaker (stiff speaker) whose resonant frequency, for example, is 50 Hz in free air, may rise to as high as 80 Hz if mounted in a small closed box. However, with Altec's latest state-of-the-art high compliance speakers, with resonant frequencies as low as 25 Hz in free air, a smaller enclosure may be used with most satisfactory results. This is because for a given size enclosure the rise in speaker resonant frequency will be much greater for a speaker with low free-air resonance than for a high resonant speaker. This means that for the high compliance, low-resonant speakers a 28-Hz speaker may only rise to approximately 40-Hz. Altec's Model 406, shown in Figure 2, is an example of such a loudspeaker for use in a small enclosure.

SPECIFICATIONS

Power Rating: 15 watts
(25 watts peak)
Frequency Response:
25-4,500 Hz
Impedance: 8 ohms
Cone Resonance: 28 Hz
Diameter: 10"
Depth: 5-1/4"
Weight: 11-3/4 lbs.

Figure 2. Model 406B Low Frequency Loudspeaker

When constructing an infinite baffle type of enclosure bear in mind that the reflecting parallel walls will create standing waves that seriously react upon the speaker impedance and response. By all means, it is recommended that opposing inner walls, except the front speaker board, be covered with some sound absorbing material. Refer to Construction Details for more information.

BASS REFLEX ENCLOSURES

As previously stated, a bass reflex enclosure consists of an enclosed volume with a port opening. Low-frequency sound radiated from the rear of a loudspeaker will "flow" around and cancel the front radiations unless a baffle separates the front from the rear. In the infinite baffle these rear radiations are trapped and lost, as far as being useful is concerned. In the bass reflex enclosure these radiations are put to work, so to speak, and permitted to aid the front radiations. By storing the sound in the enclosure and then letting it out the front through a port opening, the phase of the low-frequency sound waves is inverted and applied to enhance the front radiations. Thus, the bass reflex is often referred to as a "phase inverter".

The effect of the port in a 8 cubic-foot ported enclosure acting on the cone resonance is shown in Figure 3. The dotted curve represents an impedance response of an Altec Model 605B speaker, having a free-air resonance of 25 Hz. The solid curve

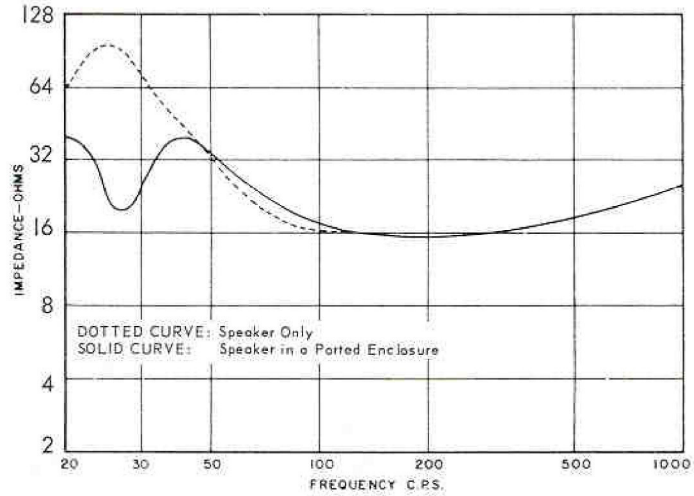


Figure 3. Model 605A Speaker Impedance Versus Frequency Chart

represents the same speaker in an enclosure having a port adjusted to produce a dip at 25 Hz, which represents an increased sound level at 25 Hz.

As shown, the combined effect is to produce a double peak that is lower in amplitude, which in effect lowers the resonant frequency of the cone and gives a more faithful reproduction of low frequencies.

The design considerations applicable to this type of enclosure are more stringent and involved than in the case of closed cabinets. The volume of the enclosure and the size of the port opening must be computed so that the resonance of the enclosure occurs at substantially the same frequency as the free-air cone resonance. When the ratio is properly chosen the result will improve the bass, which will have good transient characteristics without adding "boominess".

As shown in Figure 4, the back wave of the speaker cone in a bass-reflex enclosure is used to reinforce the bass below 150 Hz. The size of the enclosure and the tuned port shifts the phase of the back wave 180° so that it radiates from the port in phase with the front wave of the speaker to reinforce bass response.

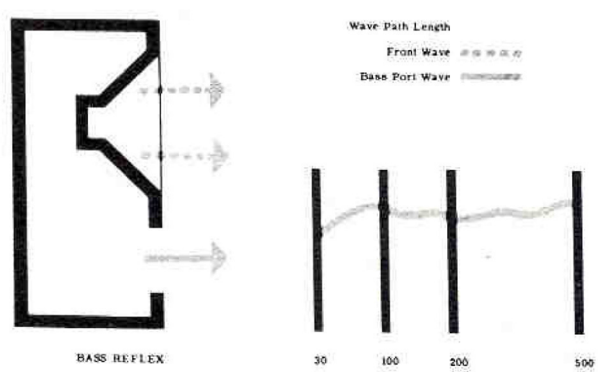


Figure 4. Bass-Reflex Enclosure Schematic

Figure 5 is a view of the Altec Lansing 846A Valencia Speaker System, which is one of the finest examples of the bass-reflex enclosure. (See Figure 13 for Construction Details.)

DETERMINING DIMENSIONS AND VOLUME

The following table lists the dimensions necessary to mount ALTEC loudspeakers. The table includes the model number of each ALTEC speaker, its total depth from front to rear, its mounting hole diameter, and its mounting-bolt circle diameter.

Table I. Mounting Dimensions and Resonance Frequencies

SPEAKER				BAFFLE	
Model	Size	Depth	Resonant Frequency (Hz)	Mounting Hole Diameter	Bolt Circle Diameter
405A*	4	2-1/8	95	4 (4-1/4 front mtg)	4-11/16
406-8C	10	4-3/4	28	9	9-5/8
411-8A	15	5-1/2	15	13-3/4	14-9/16
412-8D	12	5-7/8	39	11-1/8	11-9/16
414-8B	12	5-3/4	30	11-1/8	11-9/16
415C	15	7	27	13-5/8	14-9/16
416-8A	15	7	25	13-5/8	14-9/16
417-8C	12	5	65	11-1/8	11-9/16
418B	15	7	55	13-5/8	14-9/16
419-8B	12	5-7/8	39	11-1/8	11-9/16
420A	15	7	27	13-5/8	14-9/16
421A	15	6-1/4	40	13-5/8	14-9/16
425-8A	10	4-3/4	72	9	9-5/8
515B	15	8	25	13-5/8	14-9/16
601-8D	12	5-3/4	39	11-1/8	11-9/16
602D	15	7-1/4	25	13-5/8	14-9/16
604E	15	11-1/8	25	13-5/8	14-9/16
605B	15	10	25	13-5/8	14-9/16
615B/A	15	10	25	13-5/8	14-9/16
755E	8	2-1/4	52	7	7-5/8

*A maximum baffle thickness of 3/8 is recommended for this model. All dimensions are in inches.

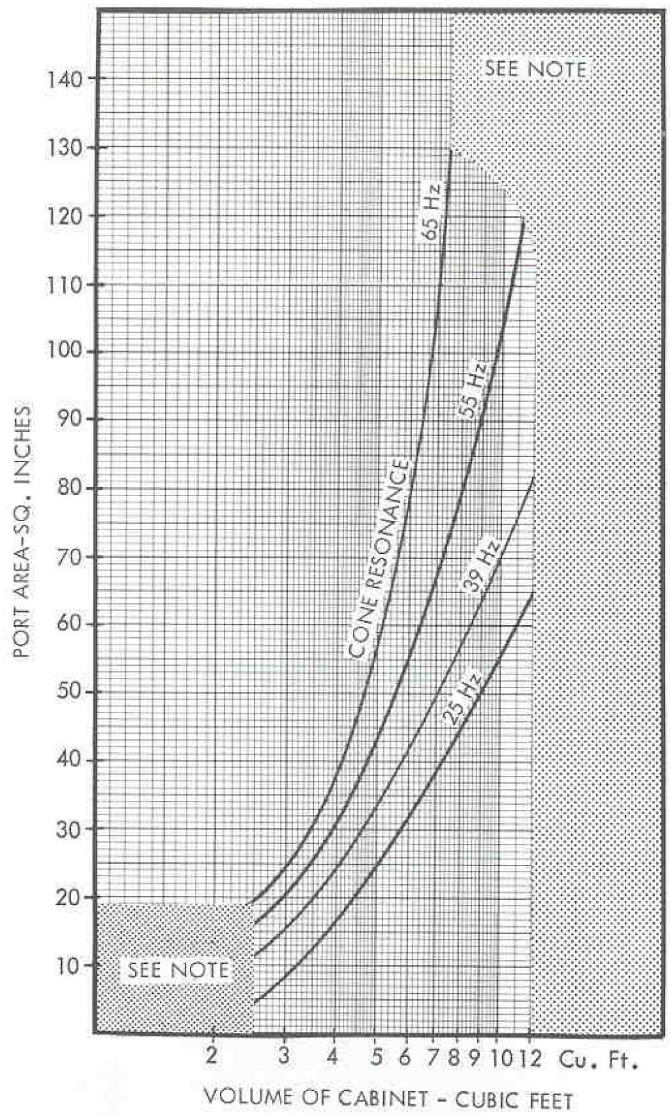
Table II. Volume Displaced by Altec Components in Cabinet

Component	Type	Volume Cubic Feet
416	15 Inch Cone	0.25
515	15 Inch Cone	0.30
414	12 Inch Cone	0.17
406	10 Inch Cone	0.10
802,808	H. F. Driver	0.026
806,807	H. F. Driver	0.023
811B	H. F. Horn	0.19 Behind Flange
511B	H. F. Horn	.42 Behind Flange
N5018A, N801-8A	Networks	.05
N800F	Network	.02

Table II lists the volume of certain speakers, horns, networks and drivers. When computing the volume, subtract the amounts listed to determine the final volume of the enclosure.

The location of the port in reference to the speaker cone opening in an enclosure is not critical, since the wave length of the frequencies in which the port opening is effective are much longer than the normal dimensions of the whole enclosure. Usually the port opening starts about 2 inches from the rim of the speaker. The height to length ratio should not be greater than 5:1, otherwise the port can be square, rectangular, or circular, provided that the area is correctly computed.

Table III. Relationship of Resonant Frequency to Enclosure Volume to Size of Port Opening in Bass-Reflex Loudspeaker Enclosures



NOTE: If the enclosure size is in the gray area an infinite baffle enclosure is recommended.

Figure 5. Model 846A Valencia Speaker System (Typical Bass-Reflex)

LOW-FREQUENCY HORNS

Low-frequency horns use a horn to couple the radiated energy of the loudspeaker to the air even more efficiently than the bass reflex or infinite baffle type of enclosure. Because the physical dimensions of lower frequency signals are by their very nature long, a horn to reproduce the bass frequencies efficiently must be quite long (over 6 feet), it is usually folded to conserve space. (Example: 50 Hz has 22.6-foot wave length and 25 Hz has 45.2-foot wave length.)

An example of the low-frequency horn is the back-loaded horn shown in Figure 6. This type of enclosure serves two purposes; it reinforces the bass by utilizing the back radiation from the cone and projects it by the means of a folded horn, while permitting the front of the cone to radiate normally as it does in an infinite baffle. The midrange and high frequencies are reproduced by a wide range single cone or a concentric speaker mechanism.

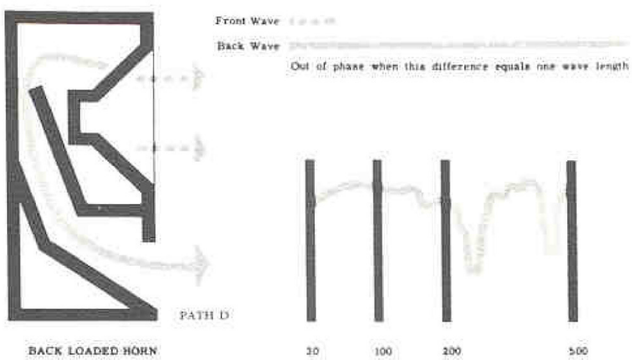


Figure 6. Back Loaded Horn Enclosure Schematic

COMBINATION ENCLOSURES

A combination of the bass-reflex and low-frequency horn enclosure (with a high-frequency horn mounted in the port) is shown in Figure 7. The enclosure is the Altec Lansing A7-type of combination enclosure. Figure 1 illustrates the same type of enclosure as that shown in Figure 7, except the high-frequency horn is mounted externally and it is the A7-500 model.

When extremely high efficiency of a loudspeaker system is desired, no better choice of enclosure than the Altec Lansing "Voice of the Theatre" can be made.

Figure 8 illustrates a response curve resulting from a combination type enclosure. Notice the increased low-frequency output as a result of the ported bass-reflex portion of the enclosure.

Since fabrication of this enclosure is a complicated task, even for experienced cabinet makers, one would do well to consider purchasing an A7 speaker system already constructed. However, for ardent enthusists who want to do it from scratch, construction plans are included in this brochure.

HIGH-FREQUENCY HORNS

Although this paper is concerned largely with enclosures and the reproduction of low frequencies, the importance of high frequency reproduction merits a few words. Altec Lansing high-frequency horns are the exponential sectoral type. They provide a flow path that directs sound waves into the proper distribution pattern at all frequencies. The performance advantages inherent in Altec horns are compared graphically to some other high frequency horns in Figure 9. Figure 10 illustrates Altec

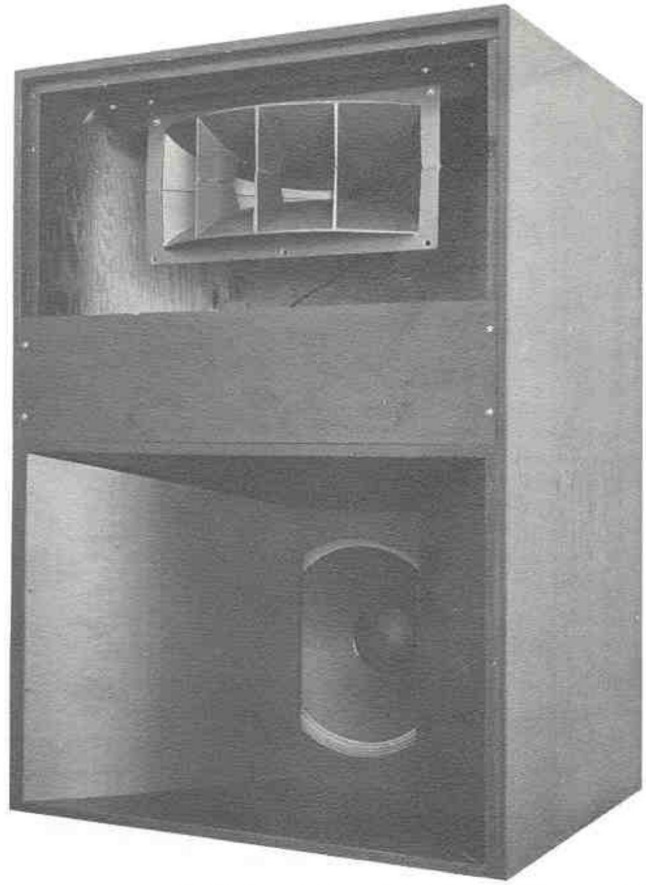


Figure 7. Model A7 "The Voice of the Theatre" System with High-Frequency Horn Mounted Inside

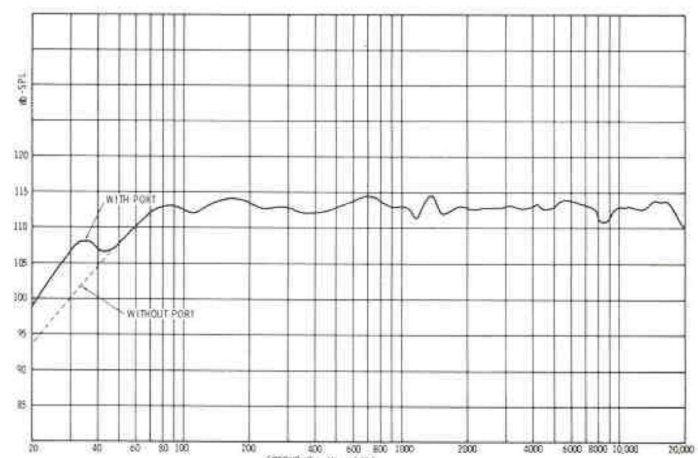
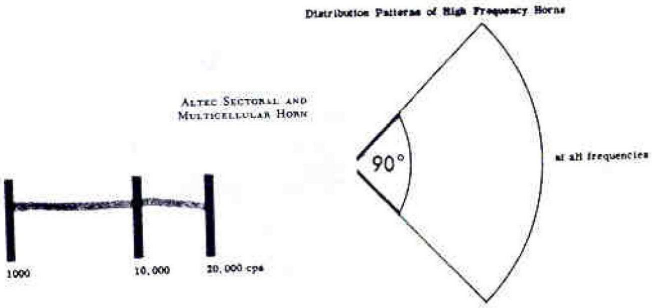


Figure 8. Frequency Response Curve of Combination Enclosure

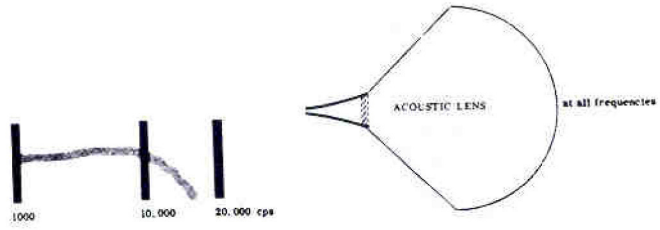
Lansing sectoral horn dimensions, including the 802D and 806A high-frequency drivers.

CONSTRUCTION DETAILS

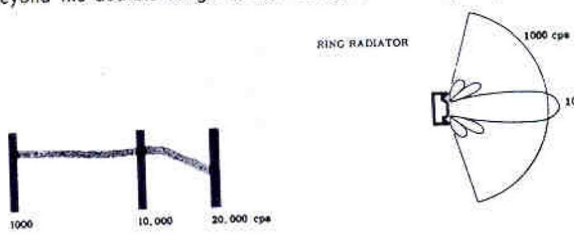
In designing and building an enclosure in any category, it is important to adhere to general rules to assure the success of the product. Any panel or baffle that is part of an acoustical system should be rigid. This is accomplished by using sufficently thick wood panels (at least 3/4 inch) and reinforcing large panels with wooden strips, such as 1" x 2" glued and nailed on edge. This will prevent drumming and resonance in the structure that would otherwise alter the response of the acoustical system. As an example, any surface that is more than 3 square feet in area should be divided into two smaller areas by a re-



A sectoral horn and the multicellular horn have excellent properties. They are built to a size which provides smooth effective distribution control from beyond the audible range to their designed low frequency limit.



The symmetrical Acoustic Lens has, at least in theory, a smooth spherical distribution pattern. Unfortunately an equal vertical and horizontal pattern is not desirable since it "bounces" sound off ceilings and floors. The frequency response of an acoustic lens is poor since the lens elements act as an acoustic filter to seriously limit high frequency reproduction.



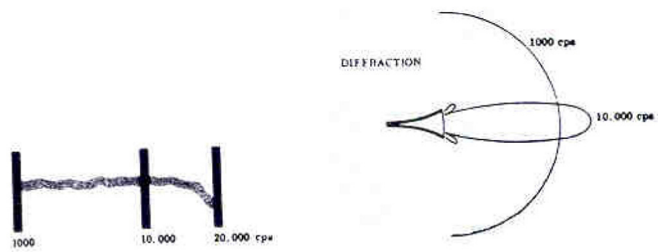


Figure 9. Distribution Patterns of High Frequency Horns

inforcing strip. The strip should be glued diagonally from corner to corner if the dimensions of the surface is approximately a square.

If the height to width ratio is less than 3:4, the strip should be glued across the smaller dimension, thus dividing the larger dimension in two equal areas. One of the most offending factors in the design of the loudspeaker enclosure is the formation of standing waves between parallel walls. As the wave leaves the rear of the cone of the loudspeaker, it will reflect from one wall and bounce to the other. If the other wall is parallel, "bouncing" back and forth will take place and will result in serious irregularities in the frequency response. It is, therefore, very important to line one or both of any parallel walls, except the speaker baffle, with a sound absorbing material such as two-inch thick fiber glass having a weight of about 6 pounds per cubic foot (available at lumber yards, hardware, and insulation stores.) If 2" material not available, 1" fiber glass will suffice.

The layer of fiber glass should, for the best performance, extend from all edges of the parallel wall so that no hard surface is exposed. It is easy to apply by using large headed nails to tack the fiber glass to the wood, or by stapling, using pieces of cardboard approximately 1-inch square under the staples.

In the case of a closed or an unused room into which a loudspeaker is backed, some means of sound absorption should be provided to prevent standing waves. If for instance, a closet is used, the normal hanging of clothing is sufficient to break up standing wave patterns. In rooms larger than a closet, ordinary drapery and carpeting is usually sufficient to prevent serious disturbances due to standing waves. In most Altec loudspeaker/enclosure systems, the speaker is installed from the rear of the baffle board. Figure 11 illustrates the proper method to mount Altec loudspeakers from the rear of the baffle board.

You are cautioned not to overtighten the mounting screws when installing any loudspeaker. Also, protect the cone assembly; all speakers should be kept face down on a clean surface until installed. The aluminum centerdome in certain extended-range speakers is particularly fragile and should not be touched. Additional loudspeaker installation and wiring instructions are provided with each Altec Lansing loudspeker when they leave the factory.

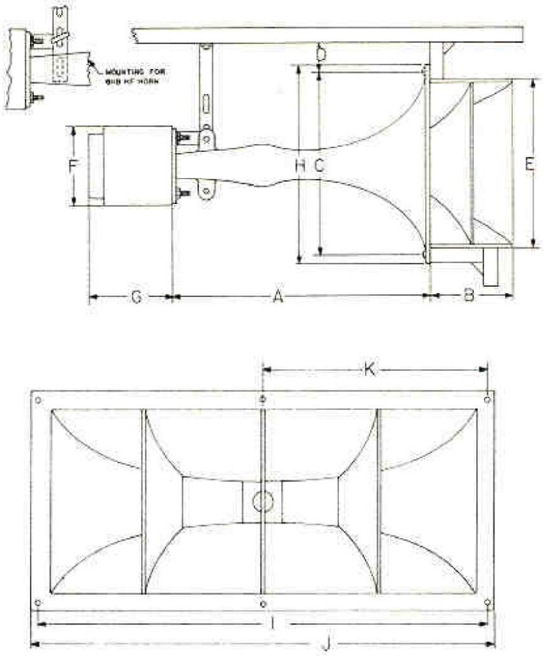
Only acoustically transparent grille cloth should be used in front of the speaker. The transmission of high frequency radiation is greatly attenuated through dense materials, such as drapery cloth or other closely woven fabrics. Decorative grilles should be chosen that are coarsely woven and have a clean surface without a fuzzy texture and that are as transparent to light as can be tolerated.

Of all the types of enclosures that are suitable to match a high-efficiency loudspeaker, the bass-reflex design is probably the most practical. Its construction is straightforward enough, however, it must be built well. The dimensions should be reasonably accurate and joints must be true and tight. Lock-mitre joints, glued under clamps, are ideal if one has access to the necessary machinery. Otherwise, all joints should be reinforced with glue blocks running the length of the joint. The glued blocks should be screwed at 4-inch intervals to each surface. If one plans to add a high frequency unit later, cover the unused baffle hole with a plywood block that is screwed down tight. The grille cloth should be stretched and tacked (or stapled) over the front of the baffle (after the baffle has been painted black.) Fasten the completed baffle to the inside edge of glued blocks (scabs) with wood screws every four inches.

Figures 12 through 15 are construction details for the A7-Series "Voice of the Theatre" Speaker System; the Model 846A Valencia; the Model 843B Malibu Speaker System; and for the Model 861A Speaker Cabinet.

TWO-WAY SPEAKER SYSTEMS

There is always a certain amount of phase shift in the cross-over frequency region that causes irregularities in the response.



	811 B	807-8A	511 B	808-8A
A	10 1/4	—	13 7/8	—
B	3 1/4	—	4 9/16	—
C	8	—	9 15/16	—
D	2 1/4	—	1 5/8	—
E	6 15/16	—	9 1/4	—
F	—	4 1/2	—	4 1/2
G	—	3 1/4	—	3 5/8
H	8 11/16	—	10 5/8	—
I	17 1/4	—	22 5/16	—
J	18 1/2	—	23 7/16	—
K	8 5/8	—	11 5/16	—

Figure 10. Altec Sectoral Horn Dimensions

This can result in listener fatigue especially if the crossover is in the upper range. You can, therefore, see that three and four-way systems multiply this problem. For this reason, most Altec systems are 2-way with the crossover points in the lower midrange for optimum performance.

It is essential to maintain proper phase relationship between the low and high-frequency units at the region of crossover. At crossover, they radiate with equal intensity, and if their phase is not correctly controlled, their outputs may cancel or combine in an unfavorable manner. For optimum performance of a dual speaker system, both the high- and low-frequency units must be in phase at the crossover region. For correct phasing at crossover, both high- and low-frequency speaker coils should be mounted in the same vertical plane.

In those installations using the Altec 811B or 511B horns with the low frequency speaker mounted on the same baffle board as the mounting flange of the horn. The voice coils are not in the same plane. Therefore, reverse the leads on the high frequency speaker for proper phasing.

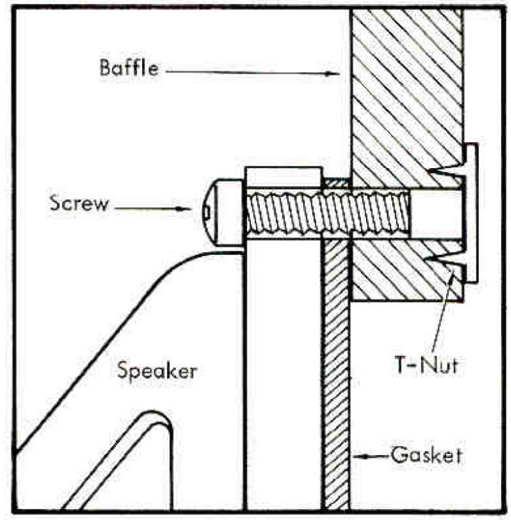


Figure 11. Rear Mounting of Altec Loudspeaker

In two-way systems it is also advantageous for the listener to be able to adjust the volume level of the components in reference to each other. Provisions have been made to do this on Altec Lansing loudspeaker systems by use of a step-switch or control on the dividing network that allows the user to shelve the high-frequency driver for establishing the best balance to fit individual room acoustics.

Room acoustics vary with the amount and placement of furniture, drapes, carpets, etc. Heavy absorption of sound waves at high frequencies takes place in a room that is heavily furnished. The absorption has the effect of deadening sound; hence, the room is "dead" acoustically. Conversely, high-frequency sound waves may bounce too freely in a room that is sparsely furnished and has many exposed wall and glass surfaces. This room is "live" and may cause excessive high frequencies for good music reproduction. The shelving control on an Altec Lansing Dividing Network enables the user to compensate for acoustical properties of the room. Critical listening with the control at various positions will enable you to determine the most pleasing degree of balance.

"STEREO" LOUDSPEAKER PLACEMENT

There has never been any problem in the proper positioning of loudspeakers as used for monophonic reproduction, but care should be exercised in speaker placement for stereo reproduction. Audience perspective is important and can best be accomplished by following a few simple, yet necessary, rules in the selection and placement of loudspeakers. To realize the optimum performance from your stereo system, it is important that the loudspeakers be placed at definite locations within the listening area.

If the speakers are too closely spaced, as in a single enclosure that houses two speakers only a few feet apart, the time and intensity difference is so small that spatial quality is severely limited. Except in a very small room, eight feet is considered minimum spacing between speakers for good stereo.

In a two-channel system, good stereo listening begins a distance in front of the speakers equal to their separation, and continues for twice this distance. For example, if the speakers are placed 8 feet apart, the best listening area extends from 8 to 16 feet in front of the speakers.

METHOD OF PHASING LOUDSPEAKER SYSTEMS IN STEREO INSTALLATIONS:

The relative phasing of the right and left hand loudspeaker units in a Stereo Home Music System is essential so that sound meant to come from the center appears to emanate from a point midway between the two speakers. Many elaborate methods for determining the correct phase are available but by using a constant amplitude frequency record, available from any High Fidelity Record Dealer, it becomes a simple matter. The 100 cycle frequency band is recommended for this purpose.

STEPS FOR PHASING STEREO SPEAKERS:

Maintain consistent polarity in wiring of your loudspeakers, carefully following the instructions furnished with your loudspeaker.

1. Listen to our system by standing directly between the right and left speakers, about eight feet in front.
2. Reverse the polarity of either the left or right loudspeaker and if the volume "goes down" your speakers are out of phase; if the volume "goes up" they are in phase. They should be left connected in the loud position.

APPENDIX

To Compute Volume in Cubic Inches:

Multiply Width x Length x Depth of Inside Dimensions = Volume in Cubic Inches.

To Convert Cubic Inches to Cubic Feet, (1728 Cubic Inches = 1 Cubic Foot): Divide Cubic Inches by 1728 = Cubic Feet.

To Convert Cubic Feet to Cubic Inches, (1 Cubic Foot = 1728 Cubic Inches): Multiply Cubic Feet x 1728 = Cubic Inches.

CUBIC FEET	CUBIC INCHES
0.1	172.8
0.2	345.6
0.3	518.4
0.4	691.2
0.5	864.0
0.6	1,036.8
0.7	1,209.6
0.8	1,382.4
0.9	1,555.2
1.0	1,728.0

CUBIC FEET	CUBIC INCHES
2	3456
3	5184
4	6912
5	8640
6	10368
7	12096
8	13824
9	15552
10	17280
11	19008
12	20736
13	22464
14	24192
15	25920

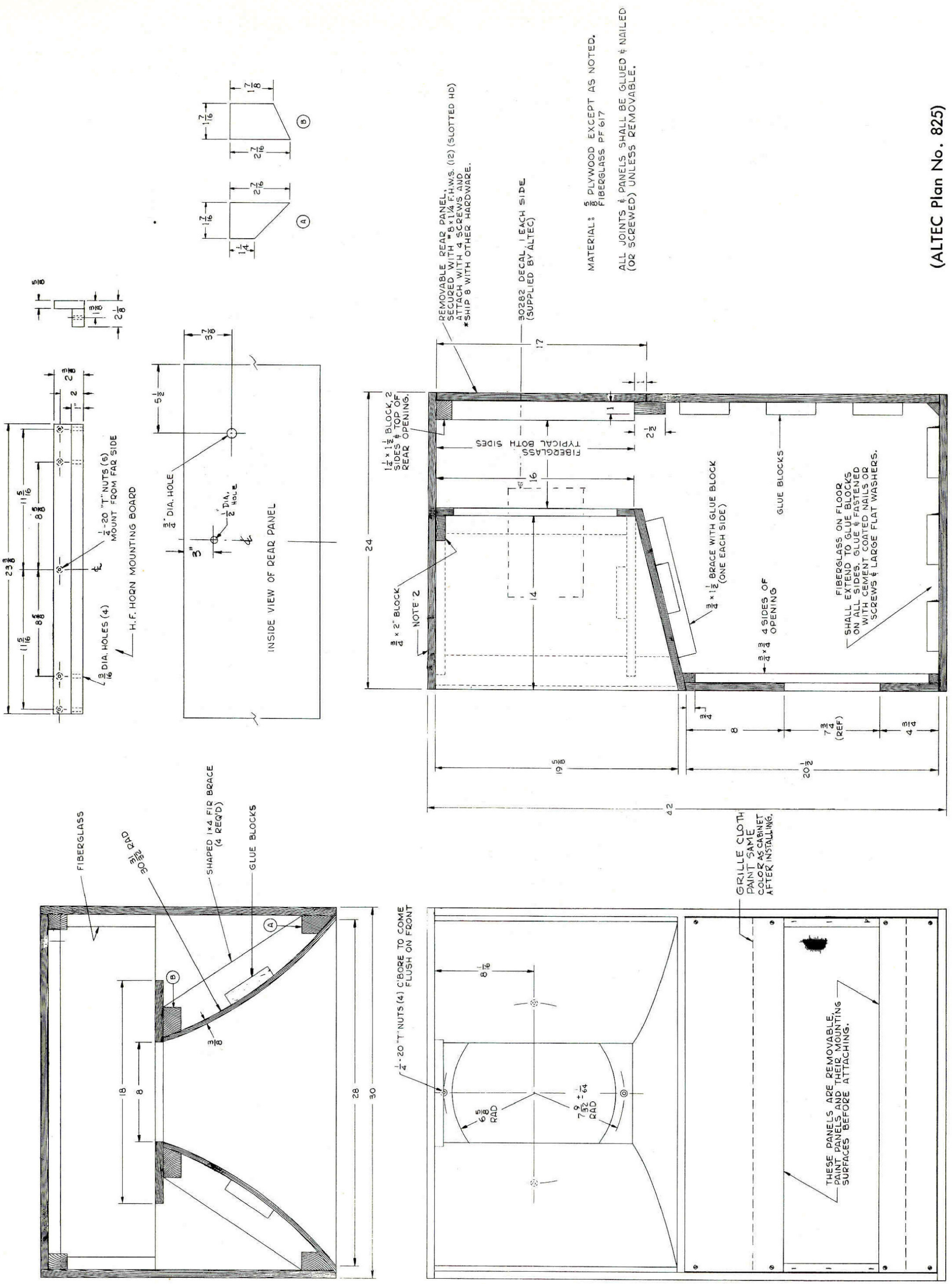


Figure 12   A7-Series Enclosure Construction Details

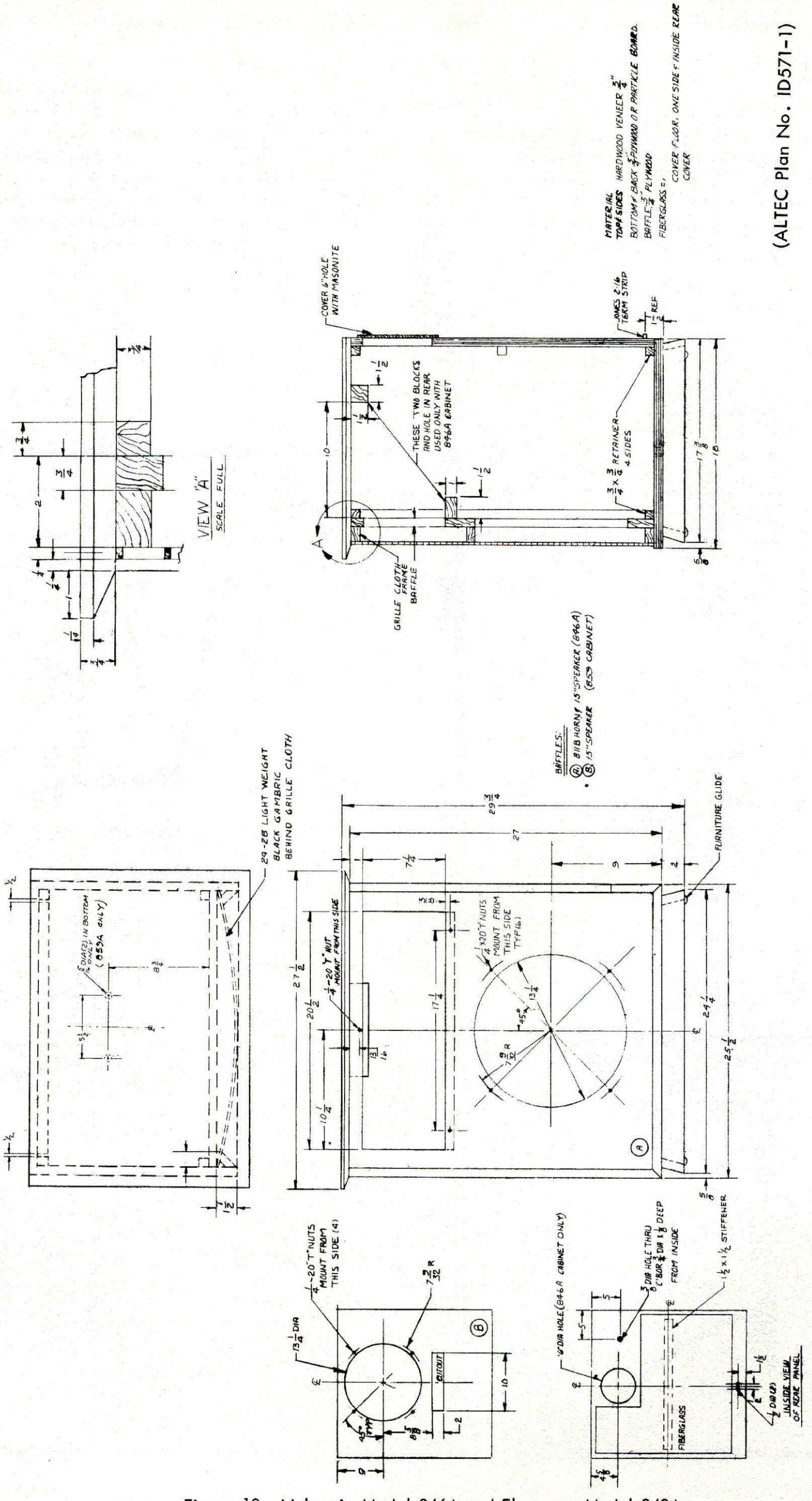


Figure 13   Valencia Model 846A and Flamenco Model 848A
Enclosure Construction Details

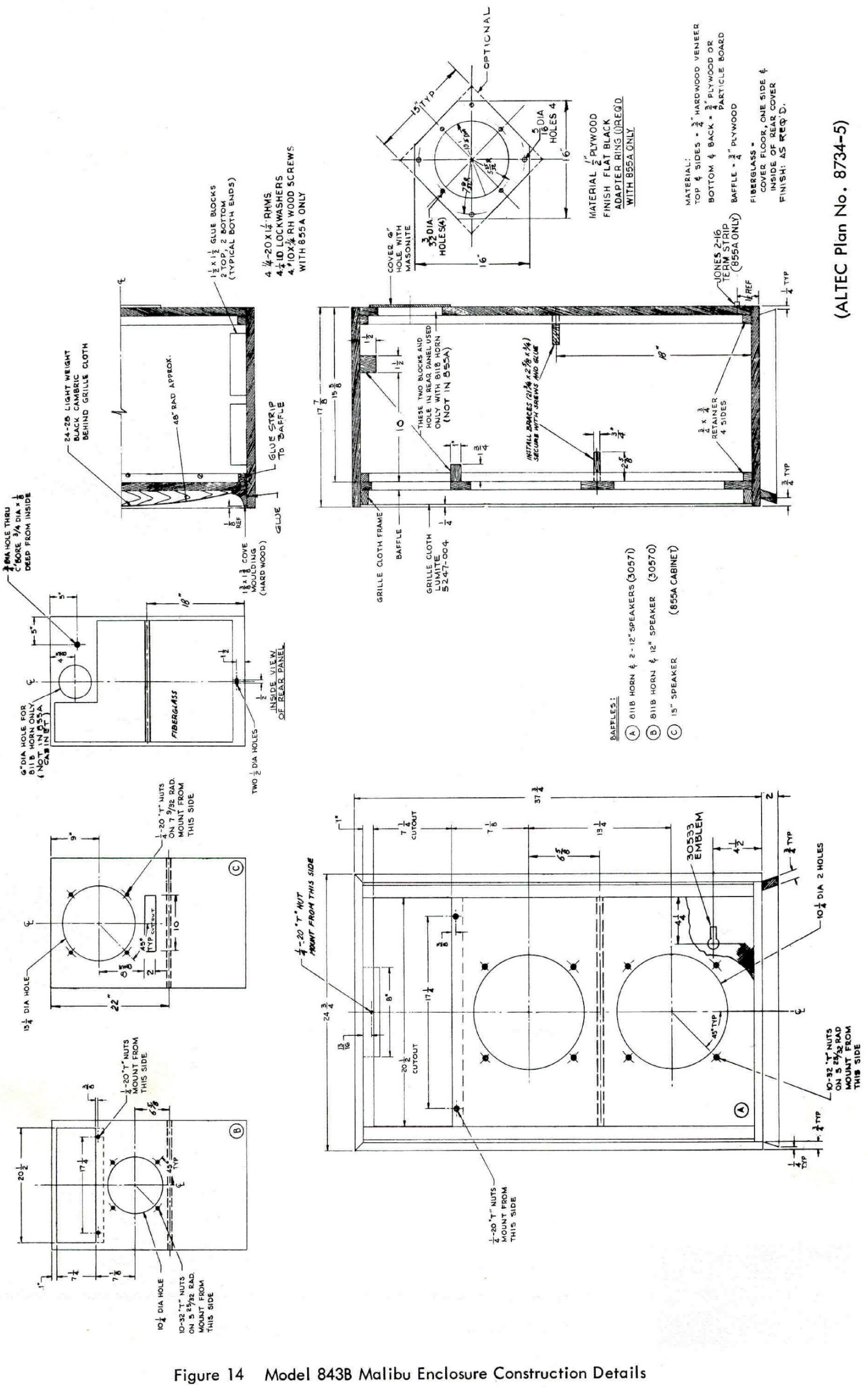
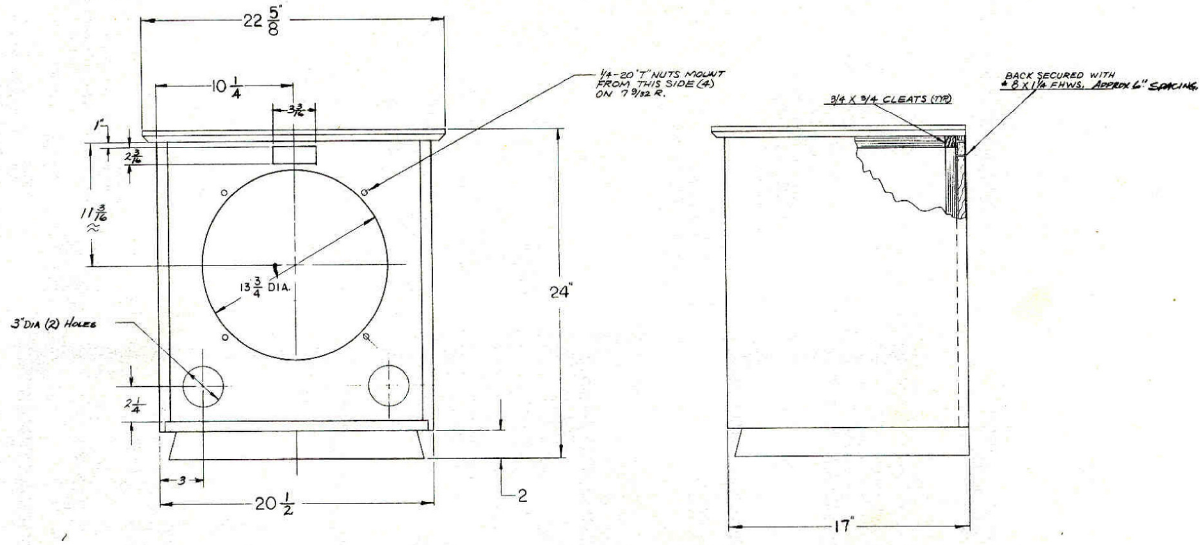
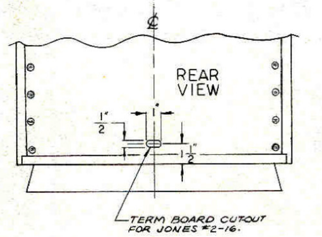
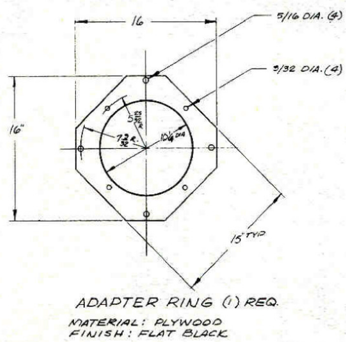


Figure 14 Model 843B Malibu Enclosure Construction Details







MATERIAL:

TOP & SIDES – HARDWOOD WALNUT VENEER 3/4" THICK.
BOTTOM & BACK – 3/4 PLYWOOD OR PARTICLE BOARD.

BAFFLE – 3/4" PLYWOOD.

FIBERGLASS – COVER FLOOR, ONE SIDE & REAR.

GRILLE – CLOTH & WOOD TRIM PER APPROVED SAMPLE.

FINISH – OILED WALNUT

INCLUDE (1) 12" ADAPTER RING – AS SHOWN – MOUNTED TO CABINET.
(1) COVER FOR HORN HOLE – MOUNTED TO CABINET

(ALTEC Plan No. ID721-1)

Figure 15 Model 861 Speaker Cabinet Construction Details

Specifications and components subject to change without notice. Overall performance will be maintained or improved.

ALTEC®

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