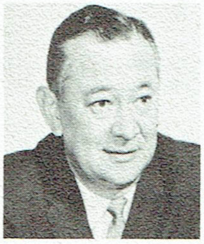
ALTEC LANSING
A Division of LTV Ling Altec, Inc.

LOUDSPEAKER ENCLOSURES
THEIR DESIGN AND USE

PRICE: ONE DOLLAR



A. BADMAIEFF
Chief Engineer
Acoustics and Transducers

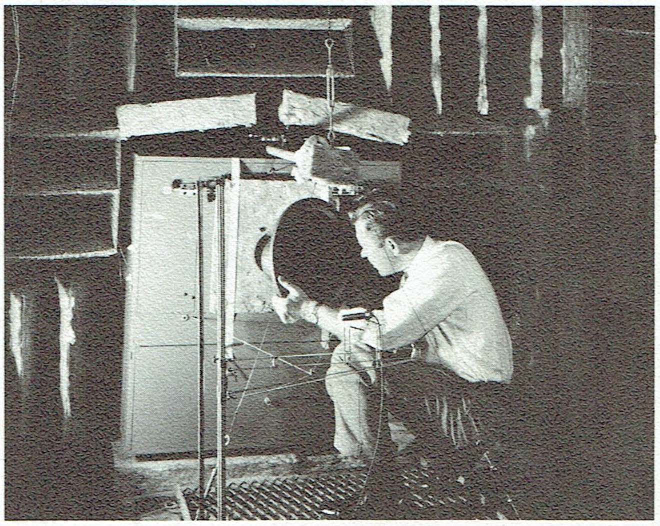
The loudspeaker enclosure design criteria set forth in this brochure is based on accepted acoustical practices and will provide the user with the finest listening pleasure when used with Altec High Efficiency Loudspeaker Components.

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 both 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 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 interfere with the radiation generated by the front of the cone. Since these two sound sources differ by 180° in phase, cancellation takes place when the wave length is long in comparison with the diameter of the cone. If the distance between the sources is increased, it will permit cancellation to occur at a lower frequency. 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.

RESEARCH AND DEVELOPMENT:

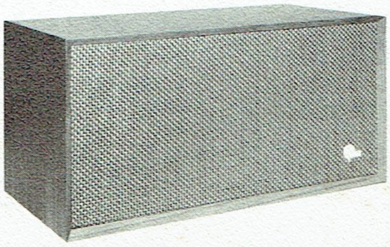
In the course of the development and design of a loudspeaker and its enclosure, many tests are essential to determine the exact performance achieved. Though many substitute tests are used, a large Anechoic Chamber is an essential acoustical tool. Other methods are poor substitutes at best. Unfortunately, for the perfection of the art, some producers of high fidelity components do not have these test facilities within their own laboratories and manufacturing plants and must, therefore, rely on compromise testing or on pure guess. ALTEC is fortunate in having one of the largest Anechoic Chambers of any electronic manufacturer and results of such tests are not left to chance, but are "plotted" automatically by a "servo" driven charting pen that qualifies the engineer's claims. Above is a photograph of the inside of one of the ALTEC Anechoic Chambers located in our Anaheim laboratories.



To outline the present day speaker enclosure types, it is first necessary to separate them into four categories:

A. Enclosures that perform as infinite baffles.
B. Enclosures that provide extended bass.
C. Projector type Enclosures.
D. Combinations.

All of the above devices perform satisfactorily within limits provided that good design procedures are carefully followed. The good and bad features of each type will be discussed in the following paragraphs.



ALTEC "VERDE" MODEL 845A

FIGURE 1

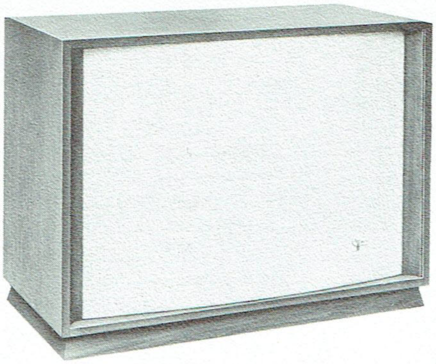
INFINITE BAFFLES: — Category A:

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 cone from "flowing" around the speaker and cancelling the front wave. It would be at least 15 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.

An example of an infinite baffle arrangement is a speaker mounted through a wall with the front of the diaphragm radiating into the listening room and the rear of the cone radiating into another room separated by the wall.

A natural trend of thought would be to fold the board into a large box that totally encloses the rear radiation. Any volume of air entrapped in such a box constitutes an added stiffness to the cone's suspension system. The stiffness must be properly correlated with the suspension system. A box of at least 15 cubic feet would be required to avoid restricted base response. However, the soft compliance type of cone suspension has made it possible to reach the lower cone stiffness through a smaller volume of entrapped air. This balance system permits smaller sized enclosures without impairment to the reproduction of the base or low frequencies.

A rear enclosure having reflecting parallel walls will create standing waves that seriously react upon the loudspeaker impedance and response. Under any condition it is recommended that the inner surface be partially covered with some sound absorbing material recommended for cabinets. Under careful laboratory controls, however, it is sometimes possible to eliminate such sound absorbing materials without impairment of results obtained. Since in the preponderance of cabinets acoustical absorbing material will improve the reproduction of sound this material should never be eliminated from your design requirements.



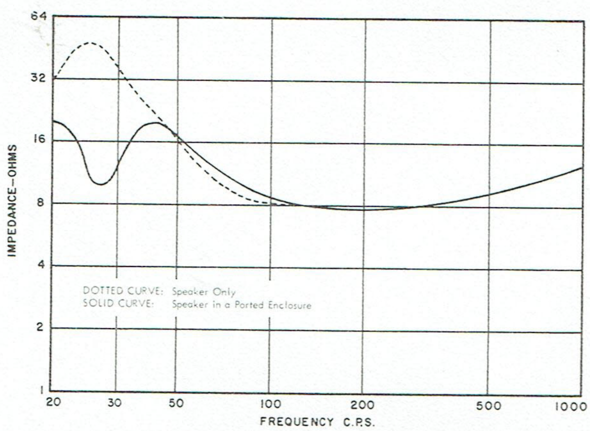
ALTEC
"CARMEL"
MODEL 838B

FIGURE 2

BASS REFLEX BAFFLES: — Category B:

(See Fig. 2.)

The bass reflex enclosure is an example of a Helmholtz resonator. It consists of an enclosed volume whose acoustical capacitance resonates with the mass of air enclosed within the confines of a port opening. By adjusting either volume and/or the area of the port it is possible to tune this resonator to a desired frequency. Because of this ability to tune the bass frequency enclosure, varied results may be obtained depending upon a number of design considerations. The typical juke box has a bass frequency enclosure tuned for the effective boom to be heard through the chatter of a public gathering. In the field of high fidelity, faithful reproduction is the designing objective to extend the low frequency response below the natural resonant point of the loudspeaker without false accentuation.



605A SPEAKER IMPEDANCE VERSUS FREQUENCY

FIGURE 3

The effect of the port in an 8 cubic foot ported enclosure acting on the cone resonance is shown in Fig. 3. Curve A is an impedance response of an ALTEC 605A speaker, having a resonance at 25 cycles. Curve B represents the same speaker in an enclosure having a port adjusted to produce a dip at 25 cycles. The combined effect produces a double peak which is much lower in amplitude. To the listener, this means a more faithful reproduction of low frequencies. The transient response of such a system is excellent which means that shock excitation due to a complex wave is damped. This permits the cone to follow a complex wave shape without overshooting beyond the instantaneous signal levels.

The design considerations applicable to this type of cabinet are more stringent and involved than in the case of closed cabinets. The volume of the cabinet 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, in order to effectively damp the cone resonance by the loading provided by the port. When the ratio is properly chosen the result will improve the bass which will have good transient characteristics without adding "boominess."

Fig. 4. presents a chart of various loudspeaker free air resonances, with the volume of the enclosure plotted against the area of the port.

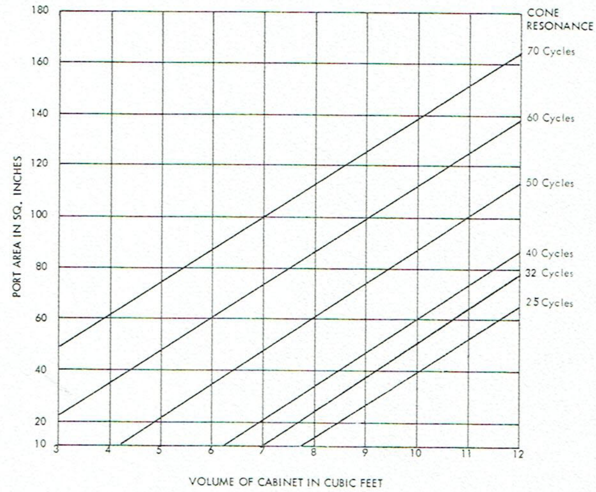


FIGURE 4

The formula for computing the volume, in cubic feet, of a loudspeaker enclosure is as follows:

Interior Measurements:

$$\frac{\underset{\text{(in inches)}}{\text{Height}} \times \underset{\text{(in inches)}}{\text{Width}} \times \underset{\text{(in inches)}}{\text{Depth}}}{1{,}728} = \text{Volume in Cubic Feet}$$

For enclosure sizes below or above the limits of the chart infinite baffles are recommended, since for a bass reflex type, the ports would be too small to be effective or too large to allow the enclosure to perform as a useful separator between the front and back wave of the loudspeaker.

For best results the depth of the enclosure should be no less than ⅓ the width, and height and width no less than twice the diameter of the loudspeaker.

A corner cabinet has an advantage. It uses the corner walls of the room as a crude horn which further improves the bass response due to additional loading of the speaker cone.

The location of the port in reference to the loudspeaker cone opening in an enclosure is not too important, since the wave length of the frequencies in which the port opening is effective are much longer than the normal dimension of the whole enclosure. Usually the port opening starts about 2" from the rim of the loudspeaker. The shape of the port also can be varied. Its aspect ratio should not be higher than 5:1, otherwise the port can be square, rectangular, or circular, provided that the area is correctly computed from the chart shown in Fig. 4. In some instances, it may be aesthetically wise to divide the port into two areas, the sum of which is equal to the total port area required for the enclosure.

A very satisfactory result may be achieved by careful application of the foregoing design data. The choice of port size as shown by the chart in Fig 4, will depend on type and size of speaker used in a system.

The following is a table listing:
Altec Duplex, Biflex and low frequency type loudspeakers, their resonant frequencies, and speaker opening diameters.

Speaker	Res. Frequency (Cycles)	Loudspeaker Opening Dia.
402B	55	6⅞″
402D	40	6⅞″
408A	70	6⅞″
412A & B	50	10¼″
412C	32	10¼″
414A	30	10¼″
415A	45	13¼″
415C	27	13¼″
416A	25	13¼″
601A & B	55	10¼″
601C	32	10¼″
602A & B	42	13¼″
602C	25	13¼″
604B, C & D	40	13¼″
604E	25	13¼″
605A & B	25	13¼″
755C	52	7″
803A	45	13¼″
803B	25	13¼″

PROJECTOR TYPE ENCLOSURES: — Category C:

Projector type enclosures involve the use of a horn to couple the radiated energy of the loudspeaker to the air even more efficiently than the bass reflex or infinite baffle type 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 six feet), it is usually folded to conserve space. These bends in the horn act as low pass acoustical filters, and therefore, attenuate frequencies above approximately 300 cycles, Fig. 7. Another example of the projector type enclosure is the back loaded folded horn, see Fig. 8. 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, and also permits 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. Instead of correcting the phase at only the crossover region, corrections have to be made along most of the range up to the mid-frequencies. Since due to folds in the horn, the distance from the listener to the front and to the back of the cone is very different, the phase will shift between the two sources as the frequency is varied. To illustrate, Fig. 8 shows this condition.

The back wave, whose path is D, must travel that distance before it combines with the front radiation of the cone. Since the two radiations are 180° out of phase, the length of path D must be one-half wave length greater for the two radiations to be additive. If, however, the wave length is equal to the distance D, complete cancellation takes place, because the two energies are 180° out of phase. At some point, usually between 200 and 500 cycles, a pronounced dip in the response is observed. This dip is inherent in this type of system because no crossover network is present between the two sides of the cone.

The only way to eliminate this interference is to provide an acoustical low-pass filter in the back loaded horn. This filter would then attenuate frequencies above, say, 150 cycles, so that the intensity of the sound from the back of the cone, amplified by the horn, would be negligible in comparison with the direct cone radiation. The acoustical filter may consist of a capacitive reactance in the form of a cavity behind the cone and a fine mesh screen in the entrance of the horn. This provides an acoustical RC circuit having the property of a low-pass filter but with only modest attenuation slope.

The design of such a system is quite involved which is evidenced by the fact that only rarely has a system of this sort really been successful. Even the best designed back loaded folded horn, provided with a tweeter and network, is really a three-way speaker system. For example, the horn and the back of the cone may reproduce all the extreme bass notes up to 150 cycles, the front of the cone reproduce up to around 3,000 cycles, and the tweeter may take over from 3,000 cycles on up to the highest treble.

A further example of the projector type enclosure is the front loaded horn. This type of horn system is generally composed of a low frequency loudspeaker with a large horn and one or more separate speakers to reproduce the midrange and upper frequencies. As the spectrum is divided into three sections a crossover network is required at each of the two crossover frequencies.

Phase relationship between the sound sources in two-way loudspeaker systems is simplified by positioning the driver units of both sound sources on the same vertical plane. However, in 3 and 4-way systems, because of the size and configuration of components, perfect phasing becomes impossible.

The front loaded horn, like the rear loaded horn, due to the physical length of the low frequency path must be folded again creating a serious phase shift because of the distance from the listener to the front and to the back of the loudspeaker cone. This differential sound path is illustrated in Fig. 7.

At some point if that difference in distance is equal to ½ wave length, cancellation occurs producing a sharply pronounced dip in the response. An obvious method to minimize this effect is to design a crossover filter having very steep crossover slopes. This, however, is troublesome and requires expensive electrical components. Another expedient, but one that makes it necessary to greatly enlarge the high frequency horn and therefore its cost, is to design the speaker system having a low enough crossover point so that actual distance of separation between the high and low frequency drivers is small in comparison to ½ wave length at the crossover length. In practical applications this crossover frequency is usually below 200 cycles.

ALTEC "VOICE OF THE THEATRE" MODEL A7

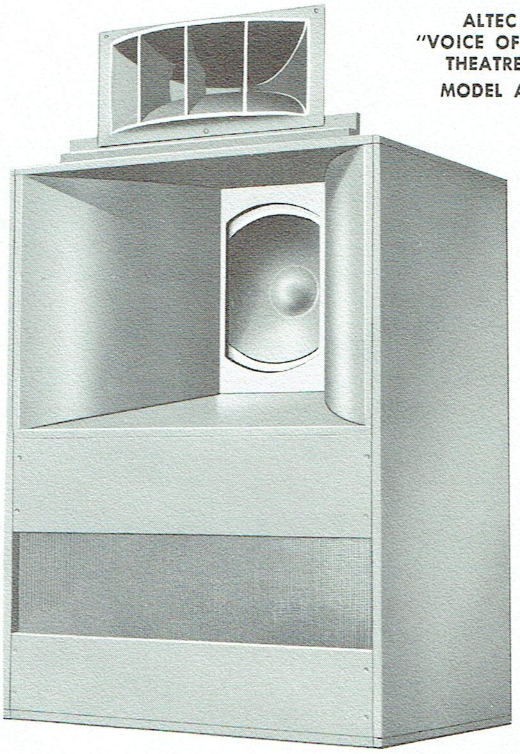


FIGURE 5

COMBINATIONS: — Category D: (See Fig. 5.)

Combinations of the foregoing systems are a possibility and some have been manufactured for many years and have proven of a superior quality in reproduction. One of the best known speaker systems of that type is ALTEC'S Voice of the Theatre line. The advantages of the extended bass response of the brass reflex enclosure, coupled to a short, direct radiating exponentially formed front loaded horn without folds, further extends the low bass range. This advantage together with the improved distribution of sound as provided by the direct radiating horn element, Fig. 6, makes this type of enclosure preferable for all types of installations.

In this type of loudspeaker system the mid-range and treble are reproduced by a smaller horn with one or more high frequency driver units. The efficiency of such systems is high providing frequency down to the lowest bass note. Since the distance of the high frequency and low frequency drivers is the same along the projection axis, perfect phasing is possible throughout the crossover region. For the transition of electrical energy to acoustic energy and where extremely high efficiency of a loudspeaker system is desired, no better choice of enclosure than the "Voice of the Theatre" can be made.

ALTEC BASS REFLEX ENCLOSURES — technically superior for smooth extended base response.

In a bass reflex enclosure the back wave of the speaker cone is used to reinforce the bass below 150 cycles. The acoustic impedance of the air in 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. The impedance of the port blocks the back wave above 150 cycles so that the front wave can operate without phase interference.

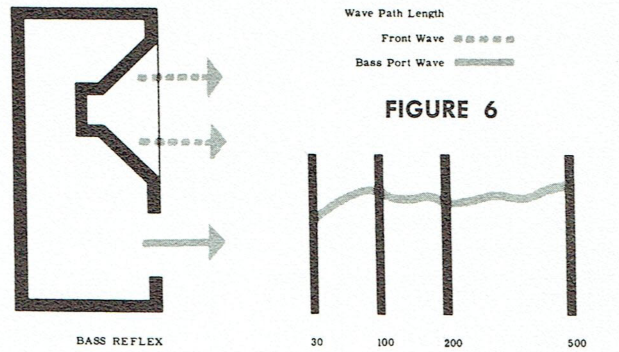


FIGURE 6

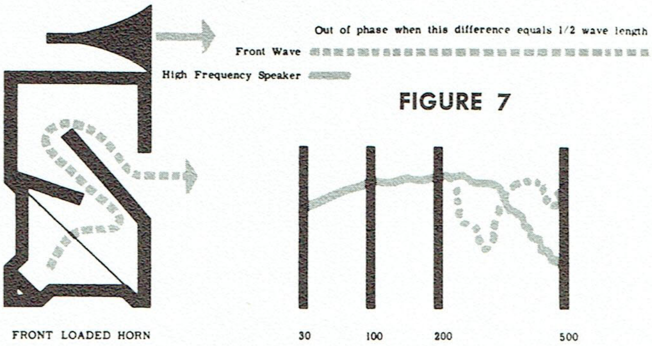


FIGURE 7

A front loaded horn operates very well in the range below 400 cycles. Above this point the horn serves as an acoustical filter and the speaker becomes inoperative. It is crossed-over to a high frequency speaker at about 300 cycles, the extreme difference in wave path length between the bass and treble sections results in phase cancellation whenever the difference in wave path length is equal to ½ of the wave length of the frequency to be reproduced. (The solid line indicates the response of a front loaded horn alone. The dotted line shows the response with a high frequency speaker crossing over at 300 cycles.)

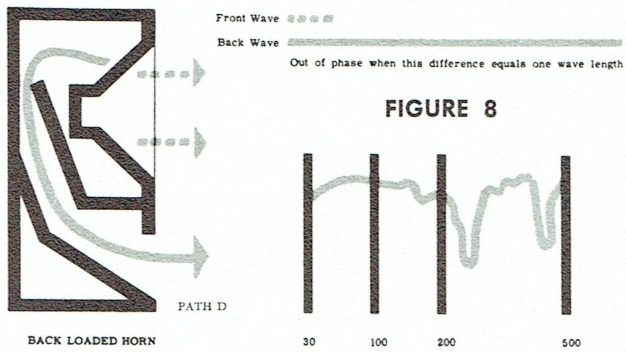


FIGURE 8

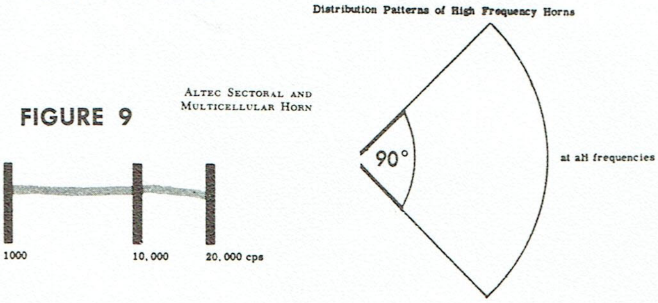
In a rear loaded horn the back wave is generated in a horn and travels a long path compared to the front wave. When this path length is the same as the wave length of the frequency to be reproduced the front and back waves are out of phase and cancel. This results in "holes" in the mid-range frequency response.

HIGH FREQUENCY HORNS

Though this paper is concerned largely with enclosures and the reproduction of low frequencies, the importance of high frequency reproduction merits a few words. ALTEC high frequency horns are of the sectoral, multicellular and direct radiator types. They provide a calculated flow path which directs sound waves into the proper distribution pattern without interfering with their natural propagation in air. The performance advantages which are inherent in these horns are compared graphically to some other high frequency horns in Fig. 9, 10, 11 and 12.

Distribution Patterns of High Frequency Horns

FIGURE 9



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.

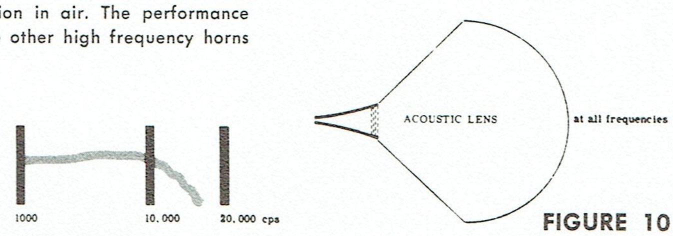
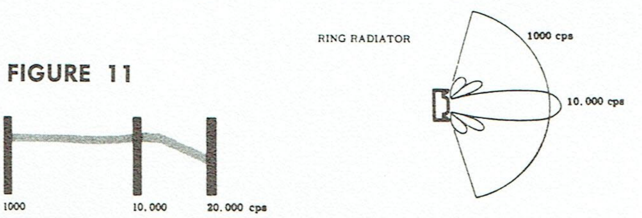


FIGURE 10

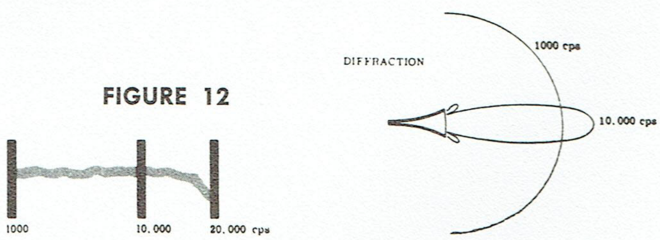
The symmetrical Acoustic Lens has, at least in theory, a smooth spherical distribution pattern. Unfortunately an equal vertical and horizontal pattern is not desirable since it "bounces" sound off ceilings and floors. The frequency response of an acoustic lens is poor since the lens elements act as an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

FIGURE 11



The Ring Radiator makes no attempt to control high frequency distribution and serves only to load the driver. As a result its distribution becomes progressively more directional at higher frequencies and at the highest pitches it reproduces only a narrow beam. In addition, due to its ring source it has regular phasing holes in its distribution pattern whenever the difference in distance between the near and far sides of the radiator equals ½ of the wave length of the frequency being reproduced.

FIGURE 12



Like the Ring Radiator, a Difraction Horn has no distribution control and does nothing more than serve as a device to load the high frequency driver. The sound waves are uncontrolled and vary from an unusably wide distribution at lower frequencies to an extremely narrow beam of sound at the higher pitches. Good listening quality can only be found directly in front of the horn.

TWO-WAY SPEAKER SYSTEM:

In a two-way system in which the woofer and the tweeter are separate, the woofer is usually enclosed in a bass reflex or infinite cabinet, and the high frequency driver with its horn mounted inside or on top of the enclosure. Suggested construction details found in Figures 13 & 14 show the methods of mounting ALTEC 3000B and 2000B High Frequency Speakers. Figure 15 details the mounting dimensions for the 511B, 811B, 802D and the 806A horn and driver units and Figures 16 and 17 are some suggested enclosure plans for these units.

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. Further improvement in phasing may sometimes be achieved by shifting the relative positions of the high and low frequency units until maximum smoothness at crossover is determined by measurements or listening tests. For the 3000B HF Speaker, the front of the horn should be in the same vertical plane with the mounting rim of the low frequency speaker.

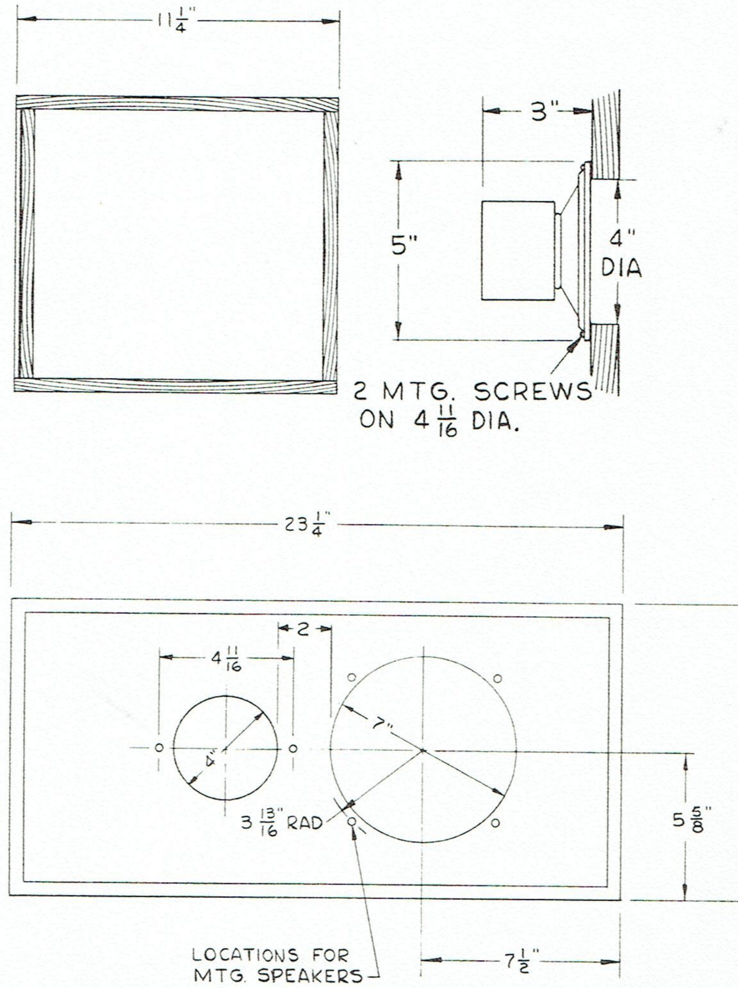
In two-way systems it is advantageous for the listener to be able to adjust the volume level of the components in reference to each other. Provision is made to do this on ALTEC loudspeaker systems by a step switch or potentiometer on the dividing network which allows the user to shelve or attenuate the high frequency driver for establishing the best balance to fit individual room acoustics. As an example, the shelving control of the ALTEC N500D Dividing Network has a four-position 1½db per-step switch. The ALTEC N3000B Network incorporates a shelving potentiometer which enables the user to continuously attenuate high frequencies to a maximum of 10 db.

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 which 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 which is sparsely furnished and has many exposed wall and glass surfaces. This room is "live" and may cause excessive high frequencies for good reproduction. The shelving control on an ALTEC dividing network enables the user to compensate for acoustical properties of the room. Critical listening with the control at various positions will enable the user to determine the most pleasing degree of balance.

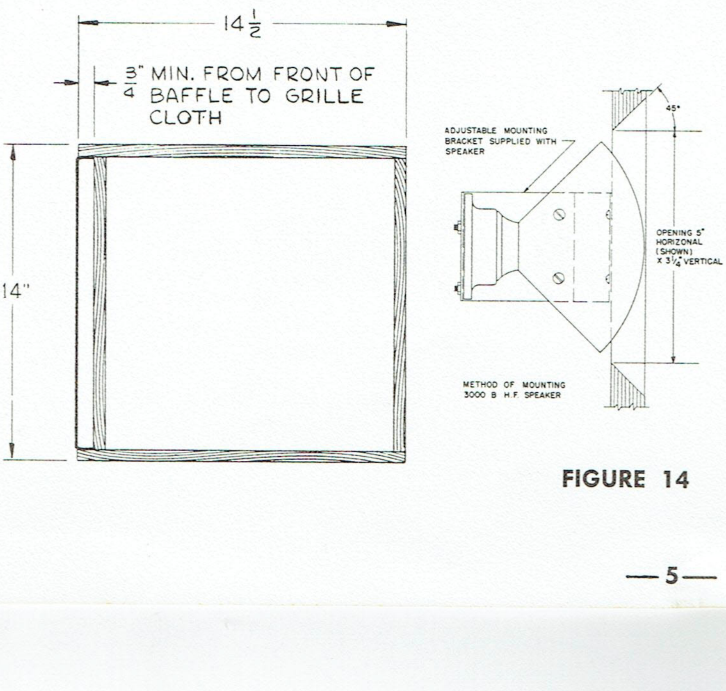
CONSTRUCTION DETAILS

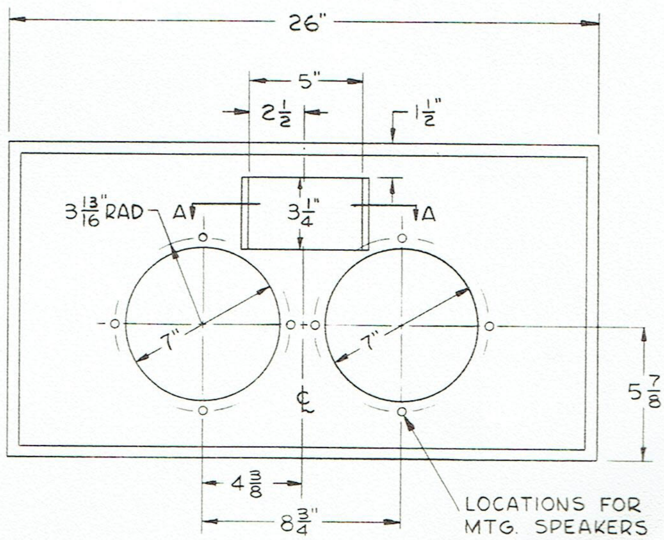
In designing and building an enclosure in any category, it is important to adhere to general rules that will decide the success of the product. Any panel or baffle that is part of an acoustical system should be rigid. This is accomplished by using sufficiently thick wood panels (at least ½ inch) and reinforcing them with wooden stripes, such as 1" x 2" glued and nailed on edge. This will prevent drumming and resonances in the structure which 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 reinforcing strip. The strip should be glued diagonally from corner to corner if the dimension of the surface is approximately a square.



A "bookshelf" enclosure recommended for Altec 402 or 755 series speakers with Altec 2000B high frequency "tweeter." (If 3000B high frequency speaker is used, horn opening should be in accordance with Figure 14.)

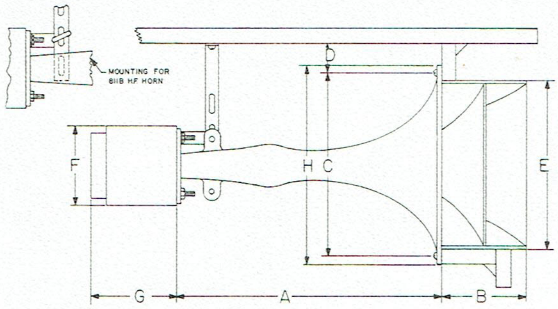
FIGURE 13





A "bookshelf" enclosure recommended for Altec 402 or 755 series speakers with Altec 3000B high frequency unit. (If 2000B high frequency speaker is used, speaker opening should be in accordance with Figure 13.)

FIGURE 14



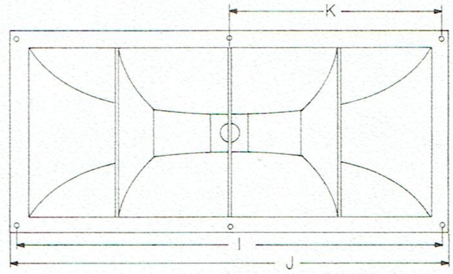


FIGURE 15

	811B	806A	511B	802D
A	10¼	—	13⅞	—
B	3¼	—	4 9/16	—
C	8	—	9 15/16	—
D	2¼	—	1⅝	—
E	6 15/16	—	9¼	—
F	—	4½	—	4½
G	—	3¼	—	3⅝
H	8 11/16	—	10⅝	—
I	17¼	—	22 5/16	—
J	18½	—	23 7/16	—
K	8⅝	—	11 5/16	—

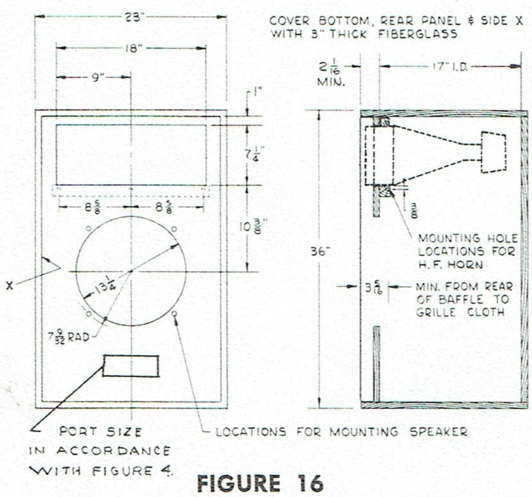


FIGURE 16

Note. Dimensions shown are for typical bass reflex enclosure for use with Altec 416A low frequency speaker and Altec 806A high frequency driver and 811B horn (and N800E Altec network). If 15″ duplex speaker Altec 602 or 605, or 12″ 601 is used, horn opening will continue to serve as bass reflex port but size of opening should be in accordance with Figure 4.

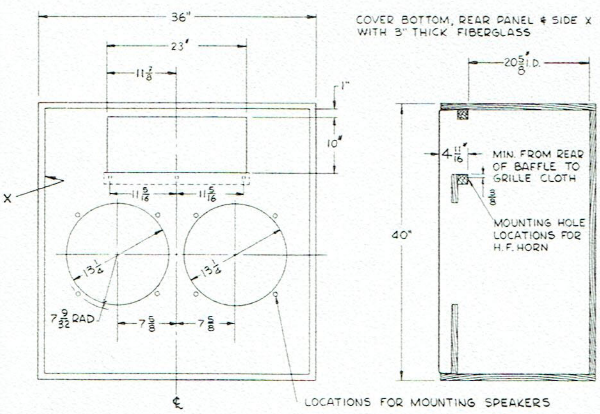


FIGURE 17

Note. Dimensions shown are for a typical infinite enclosure for use of two Altec 416A low frequency speakers and Altec 806A high frequency driver and 511B horn (and N500D Altec network).

If the aspect ratio is less than 3:4, the strip should be glued across the smaller dimension, thus dividing the larger dimension in two equal areas. As mentioned before 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 with a sound absorbing material such as three inch thick (total) Owens-Corning Fiberglas board having a weight of about 3 pounds per cubic foot (available at hardware and insulation supply stores).

The layer of Fiberglas 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 any of the commercial adhesives available on the market today, and insuring the permanence by reinforcing the Fiberglass layer with nails and fairly large washers tacking the Fiberglass to the wood. It is unnecessary to line all the walls of an enclosure, since sound is absorbed if any one of the two parallel walls is lined with sound absorbing material. 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.

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.

NOTES:

Cabinets, Fig. 16, and Fig. 17 are shown with mounting diameters for 15″ speakers. When 12″ speakers are used, make mounting hole 10¼″ in diameter.

Cabinet, Fig. 14 is for an 8″ woofer and high frequency unit. The 5″x3¼″ cut out directly above the speaker mounting holes permit installation of the 3000B High Frequency Speaker for a compact two-way system. It is suggested that even if the HF Speaker is not used in the initial installation, the cut out be made and solidly replugged to permit easy addition of this unit at a later date.

"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 loud speakers be placed at definite locations within the listening area.

Two separate channels, that originate from a dual amplifier, are fed to the speakers, provide the phase and amplitude difference that gives the spatial quality to "stereo." If the speakers are too closely spaced, as in a single enclosure which 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. In three-channel systems the center speaker should be located as near midway between the two side speakers as possible and ideally in line. The use of the third speaker allows wider spacing of the side speakers and a correspondingly broader listening area.

High-quality stereo home music components have provisions for connection of a center, or third, channel speaker, or provide a voltage source capable of driving a third channel amplifier.

In operation, the center speaker reproduces the signal existing in both side speakers. The sound that originated from the center of the recording stage, as in recording a soloist, will actually radiate from all three speakers but will appear to be confined to the center channel. With two speakers not too widely separated this effect is preserved without the center speaker; but the third speaker will permit a much wider separation of speakers and spread of sound source without an undesirable "hole in the middle" effect.

A large spread between speakers is permissible if the listening area is moved back proportionately. Listening too close to two widely separated speakers creates a "hole in the center" which gives the impression of two distinctly separate sound sources rather than the desired broad front of sound. In a three-speaker system, the hole in the middle is much less likely to occur, but extreme separation will lead to "holes" between speakers or a loss of source width apparent in parts of the listening area. If speakers are substantially separated, it is generally best practice to "angle" the side speakers toward the center of the listening area.

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 appear 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 your 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.

CHANNEL BALANCE FOR STEREO LISTENING:

The Balance or "spatial" control is used to compensate for slight differences between the two channels in a stereo system. These differences may be mismatches in the pickup cartridge, speakers, tape heads, the recording itself, etc. Since faithful reproduction of the stereo effect demands that the two channels be identical, the Balance control should be adjusted until the sound centers properly. With channel unbalance, the sound appears to originate in either the right or left speaker. When the adjustment is nearly correct the stereo effect will be noticeable but not centered. With the correct adjustment the full stereo effect is obtained — orchestral music is distributed by instruments, uniformly across the space between the speakers, and a soloist is usually on center.

A constant tone frequency record fed into both channels will suffice. By proper setting of the balance or "spatial" control or of the individual volume controls on each channel, the sound emanating from both left and right loudspeakers will be the same. When these signals are of the same level, your system is in balance and best reproduction from your system is assured.

GENERAL:

ALTEC enclosures are designed to fully complement ALTEC loudspeakers. To prevent future disappointment, if loudspeakers other than ALTEC are to be used in these enclosures, it is suggested that their manufacturer be contacted for advice on efficiency, resonance, impedance matching, and phasing since no enclosure can improve the performance of a poorly constructed, low efficiency speaker.

Loudspeaker efficiency is so vital to performance that it should not be overlooked. The formula $DB = 10 \log \frac{P_1}{P_2}$ may be used to illustrate the effects of low efficiency. The exceptional performance of ALTEC loudspeaker systems is due in part to a very high efficiency of the loudspeakers. A loudspeaker only 3 db less efficient than ALTEC's requires twice the power to obtain the same sound level in a room. A speaker 6 db less efficient requires 4 times the power, 9 db requires 8 times the power, and a speaker system 12 db less efficient actually requires 16 times the amplifier power output to achieve the same sound level. For the 8 watts required by an efficient ALTEC system to faithfully reproduce dynamic peaks in music, some low efficiency speakers require a peak power amplifier output in excess of 120 watts to obtain *concert listening level*. The problem of supplying the speaker with such an amount of power does not end in the impracticability of installing and ventilating a huge power amplifier. A residential loudspeaker is simply incapable of handling a power input of this magnitude and must distort or compress the dynamic peaks in the music.

A high fidelity system is only as good as its weakest component. The superior ALTEC loudspeaker will perform well even under unfavorable conditions of poor source and amplification, however, when starting a new hi fi system or improving the old one, it is worthwhile to investigate the entire line of ALTEC high fidelity components. There is an ALTEC tuner, power amplifier, control preamplifier, amplifier-preamplifier combination, and microphone to suit any system and budget. ALTEC components are matched and balanced as your assurance of faithful reproduction that is truly high fidelity. Complete information on ALTEC High Fidelity may be obtained by writing for the ALTEC catalog.

ALTEC PLAYBACK SPEAKER COMPONENTS

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.

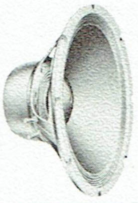
YOUR GUIDE TO CUSTOM ALTEC TWO-WAY SPEAKER COMPONENT SYSTEMS

ALTEC LOW FREQUENCY SPEAKERS	ALTEC HIGH FREQUENCY SPEAKERS	DIVIDING NETWORKS	SYSTEM CROSSOVER FREQUENCY
2-416	802 on 511B	N-500D	500 cycles
2-416	806 on 811B	N-800E	800 cycles
2-414	806 on 811B	N-800E	800 cycles
416	802 on 511B	N-500D	500 cycles
416	806 on 811B	N-800E	800 cycles
414	806 on 811B	N-800E	800 cycles
414	3000	N-3000E	3000 cycles
415 or 412	3000	N-3000E	3000 cycles
755 or 402	3000	N-3000E	3000 cycles
DUPLEX SPEAKERS			
601	Coaxially mounted	Matching network included	3000 cycles
602	Coaxially mounted	Matching network included	3000 cycles
604	Coaxially mounted	Matching network included	1500 cycles
605	Coaxially mounted	Matching network included	1600 cycles

LOW FREQUENCY SPEAKERS

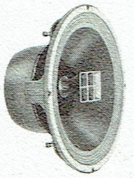
414A
12″ Diameter
30 to 4,000 cycles frequency response
25 watts power rating
16 ohms impedance

416A
15″ Diameter
20 to 1,600 cycles frequency response
30 watts power rating
16 ohms impedance



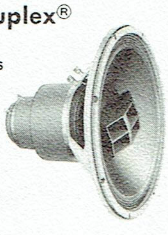
DUPLEX® SPEAKERS

601C
12″ Diameter
30 to 22,000 cycles frequency response
20 watts power rating
8 ohms impedance

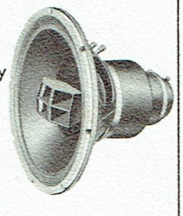


602C
15″ Diameter
20 to 22,000 cycles frequency response
25 watts power rating
8 ohms impedance

604E Super Duplex®
15″ Diameter
20 to 22,000 cycles frequency response
35 watts power rating
Impedance: Designed to operate from 8 or 16 ohms

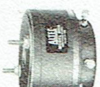


605B
15″ Diameter
20 to 22,000 cycles frequency response
35 watts power rating
Impedance: Designed to operate from 8 or 16 ohms

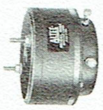


HIGH FREQUENCY HORNS AND DRIVERS

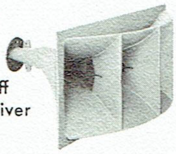
802D
4½″ Diameter, 3¹¹⁄₁₆″ Deep
500 to 22,000 cycles frequency response
30 watts power rating
16 ohms impedance



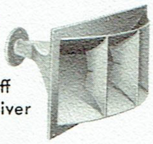
806A
4½″ Diameter, 3¼″ Deep
500 to 22,000 cycles frequency response
30 watts power rating
16 ohms impedance



511B
90° X 40° sound distribution
500 cycle low frequency cutoff
802D or 806A Driver may be used

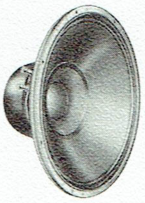


811B
90° X 40° sound distribution
800 cycle low frequency cutoff
802D or 806A Driver may be used

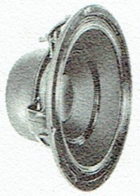


FULL RANGE SPEAKERS

415C Biflex®
15″ Diameter
25 to 14,000 cycles frequency response
25 watts power rating
8 ohms impedance



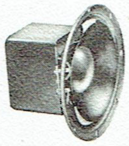
412C Biflex®
12″ Diameter
30 to 15,000 cycles frequency response
20 watts power rating
8 ohms impedance



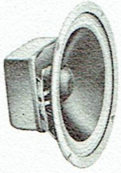
755C
8″ Diameter
40 to 15,000 cycles frequency response
15 watts power rating
8 ohms impedance

SMALL TWO-WAY SPEAKER COMPONENTS

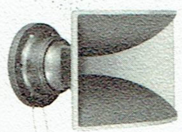
2000B High Frequency Speaker
5″ Diameter
1,500 to 18,000 cycles frequency response
14 watts power rating
8 ohms impedance



402B Bass Speaker
8″ Diameter
40 to 10,000 cycles frequency response
14 watts power rating
16 ohms impedance



3000B High Frequency Speaker
90° X 40° sound distribution
3,000 to 22,000 cycles frequency response
20 watts power rating
8 ohms impedance



NETWORKS

N-500D
Impedance: Designed to operate from 8 or 16 ohms
4-1.5 db steps hf shelving attenuation
500 cycle crossover frequency

N-3000E
8 ohms impedance
10 db continuously variable hf shelving attenuation
3000 cycle crossover frequency

N-800E
Impedance: Designed to operate from 8 or 16 ohms
4-1.5 db steps hf shelving attenuation
800 cycle crossover frequency