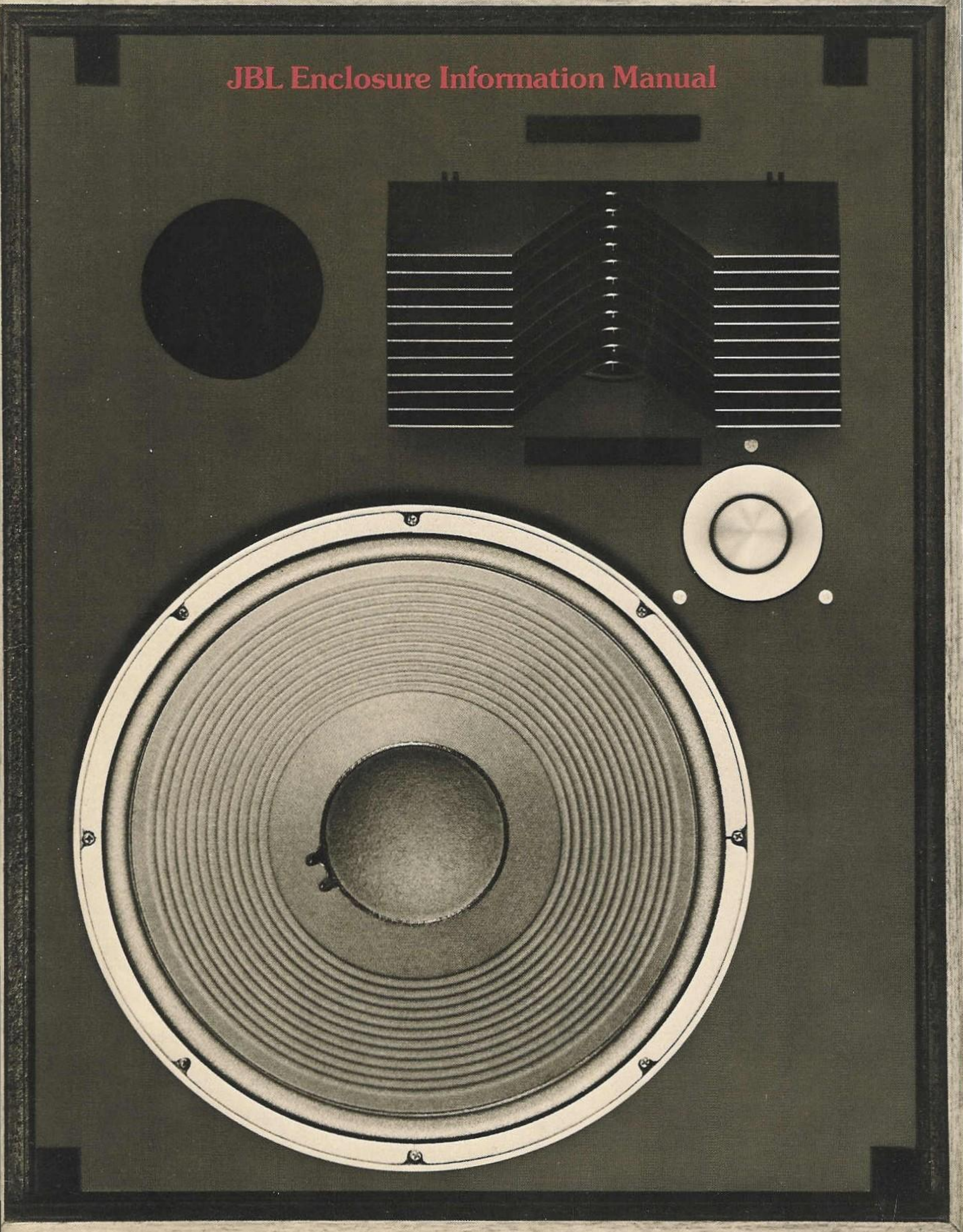
JBL Enclosure Information Manual



Contents

How To Use The JBL Enclosure Construction Kit

This package of materials contains all the instruction you will need to build an enclosure for JBL musical instrument loudspeakers or home entertainment systems. Using hand tools and armed with a rudimentary knowledge of woodworking, you can construct enclosures that perform like JBL's if you carefully follow directions.

The booklet you are now reading comprises five parts. Parts One and Two contain background information to give you a better understanding of the elements that contribute to the sound which is the final result of your efforts. Part Three deals with home entertainment enclosures, and Part Four relates to musical instrument loudspeaker enclosures.

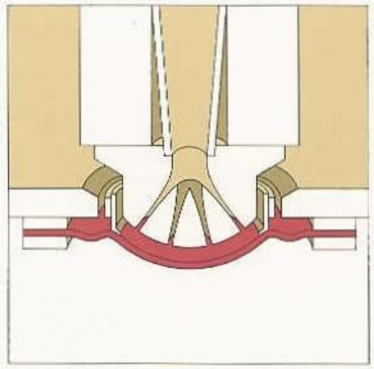
Construction techniques are discussed in some detail in Part Five and are applicable to whatever type of enclosure you are building. This fifth part should be read carefully before beginning construction.

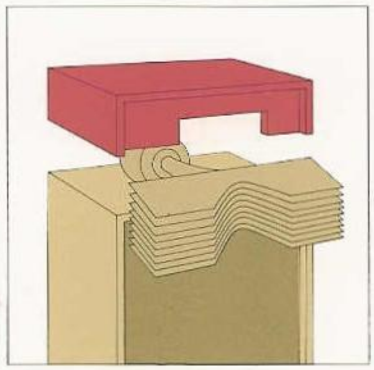
The other materials included in this package are enclosure blueprints and baffle board configurations.

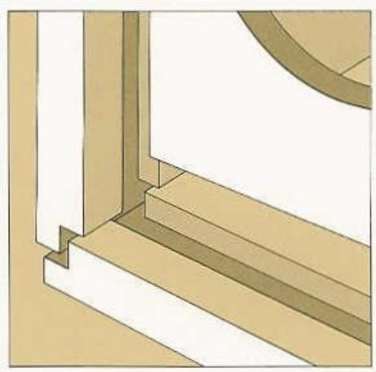
The baffle drawings list those JBL loudspeakers which are suitable for the particular enclosure. These baffle drawings will also show you loudspeaker placement, cut-out sizes and all necessary porting information.

Should you desire to build an enclosure of different dimensions than those suggested, you will still find valuable information in this booklet. The construction techniques will still be applicable, and the separate porting charts will provide information for any reasonably sized enclosure you may construct. Advice on porting is offered in the Appendix for loudspeakers other than those of JBL manufacture.

As you proceed with the construction of your enclosure, remember that the JBL Technical Services Department is ready to assist you if you have a problem that is not covered in this body of information; just call or write.







Part 1

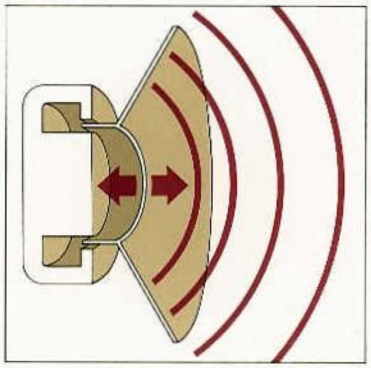
Understanding What You Are Dealing With

Building your own loudspeaker system involves considerably more than merely choosing a speaker or two and installing them in just any box. Loudspeakers must be carefully matched and housed in enclosures which will complement their operating parameters, so that the full performance designed into them can be achieved.

It is beyond the scope of this manual to provide a learned explanation of the advantages and disadvantages of different loudspeaker designs and enclosure principles, or to offer a full discussion of JBL's engineering philosophy and manufacturing expertise.

It is necessary, however, to understand some of the basic principles before proceeding.

Some Basics



A loudspeaker is a mechanism with a piston that moves back and forth, creating pressure waves in the air.

A loudspeaker is a mechanism with a piston that moves back and forth, creating pressure waves in the air. When these pressure waves strike the listener's eardrums, sound is heard.

If the piston moves back and forth 41.2 times per second, the listener will hear a tone whose pitch corresponds to that of the lowest note on a bass viol or electric bass guitar (low "E"). As the piston vibrates more and more times per second, the pitch of the tone rises accordingly. Each time the frequency of vibration doubles, the pitch goes up one octave. For example, a rate of 440 cycles per second, or 440 hertz (abbreviated "Hz"), represents the pitch of the open "A" string of a violin, and is one octave above the open "A" on a cello (220 Hz).

This moving piston may be made of a number of different materials. The most common loudspeaker design uses a paper cone as a piston; however, other materials are employed, such as aluminum and phenolic —particularly in units designed to reproduce the upper range of the frequency spectrum. Other materials used include styrene, beryllium and polyester films.

In order to create these pressure waves, the piston must be moved by some type of motor. Although a number of different methods have been used to drive the piston, the earliest system used for driving loudspeaker mechanisms, the "dynamic," is still the most efficient and most often employed.

The dynamic loudspeaker uses the fundamental interlocking relationship between electricity and magnetism as the basis for driving the piston.

When an electrical current flows through a wire, a weak magnetic field is created around the wire.

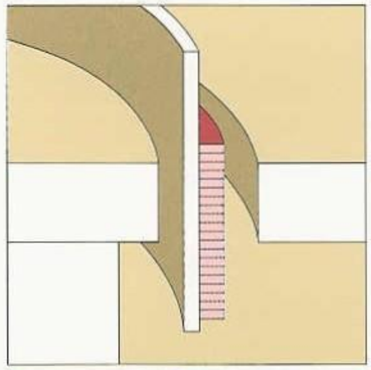
If the wire is coiled, the magnetic field will be correspondingly increased.

If this coil of wire is placed in another magnetic field, any field from the coil will interact with the external field. Depending on the orientation of the external field and the direction of current flow in the coil, the coil may be attracted to or repulsed from the external field.

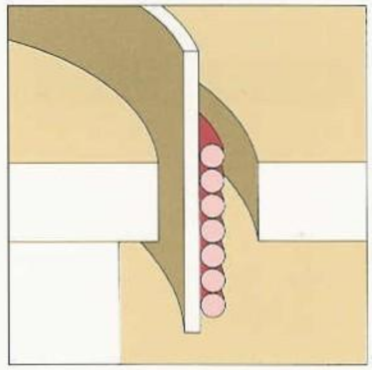
If the coil is attached to the loudspeaker's piston and is in a fixed (i.e. non-varying) magnetic field, the result is a dynamic loudspeaker and the coil is then called a "voice coil."

The stronger or more concentrated the fields induced by the magnet and the voice coil are, the more movement of the piston will result.

In order to create a maximum amount of field strength, most JBL voice coils are made with rectangular wire which is hand wound on edge. By doing this, it is possible to put approximately 25% more wire in the same area compared to round wire. All of the magnetic force is concentrated in a precisely machined gap in which the voice coil moves. Heavy magnetic iron structures are used to direct the force into the gap. The precise machining of the parts and JBL's extremely tight manufacturing tolerances ensure optimum utilization of the magnetic force. This increases efficiency and improves overall performance.



In order to create a maximum amount of field strength, most JBL voice coils are made with rectangular wire which is hand wound on edge.

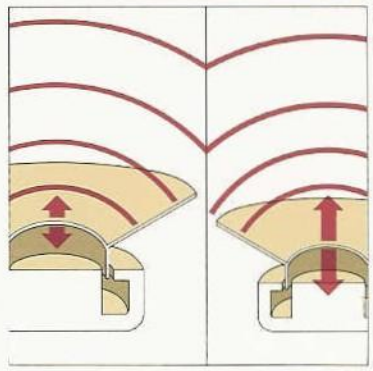


Rectangular wire allows approximately 25% more wire in the same area compared to round wire.

Efficiency

Efficiency is a measure of how much of the electrical power sent into the loudspeaker by the amplifier is converted into acoustical power. A high efficiency loudspeaker will create a louder sound than a low efficiency system when both are sent the same amount of power from an amplifier.

Several different factors enter into the efficiency of a loudspeaker. The strength of the magnetic field in the gap, as discussed before, is important, as is the strength of the field around the voice coil and the weight of the cone. At low frequencies, the size of the cone affects efficiency, since a larger cone can take a bigger "bite" on the air and need not move as far as a smaller one to create equal sound pressure levels, all other things being equal. As will be discussed in detail later in this publication, the enclosure design also will affect the efficiency at low frequencies.



At low frequencies, the size of the cone affects efficiency, since a larger cone can take a bigger "bite" on the air and need not move as far as a smaller one to create equal sound pressure levels, all other things being equal.

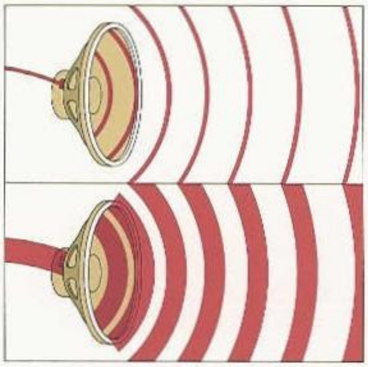
The efficiency specifications of the loudspeakers and of the systems are intended to provide the user with a realistic idea of their relative loudness. The method used to express efficiency is called "sensitivity," and is stated as the sound pressure level, measured on axis at a distance of one metre (3.3 feet), produced by the loudspeaker or system from an input signal of one watt*

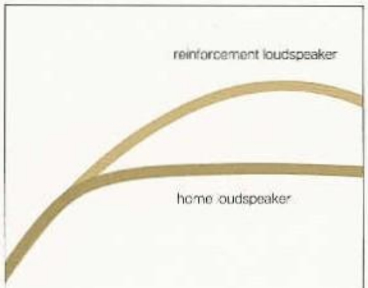
High efficiency has always been a hallmark of JBL loudspeaker designs. Their original application – motion picture sound reproduction for the first "talkies" – demanded that they fill large halls with sound, using only the low-power amplifiers that were then current. Among his many achievements, James B. Lansing perfected the technique for milling flat wire and for winding ribbon voice coils, and made vital contributions to compression driver technology. His high efficiency designs were so advanced that many of them, substantially unchanged, are in production to this day.

The sensitivity specifications are given in decibels (dB), which measure relative acoustic levels. 75 - 80 dB is a comfortable listening level. In order for sounds to be twice as loud to the ear, the sound pressure level must be increased by about 10 dB, and to get 10 dB more sound pressure level out of a system, the amplifier power applied to the system must be multiplied by

*Sensitivities are averaged over the usable frequency range of the driver; the frequency range is included in the driver's specifications.

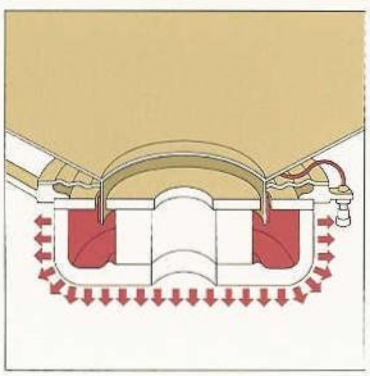
The power from the amplifier must be increased by a factor of 10, resulting in 10 dB additional sound pressure level, in order for the ear to perceive doubling of loudness.





Below a certain frequency, a home loudspeaker and a speech reinforcement loudspeaker may have identical deep bass response. However, since the midrange energy output of the reinforcement unit is much greater than that of the music speaker, the speech unit may appear deficient in deep bass.

Amplifier power is sent through the voice coil and heat is generated in the coil. A large and heavy magnetic structure will be able to act as a "heat sink," accepting the heat from the voice coil and transferring it into the air.



ten. Doubling amplifier power to a system will result in only 3 dB additional sound output, which is noticeable but not nearly twice as much level.

Efficiency vs Low Frequency Response

A loudspeaker intended to reproduce low frequencies in an auditorium installation for speech reinforcement should have very high efficiency, since this application requires maximum sound output for a given amount of amplifier power to keep system cost down. Deep bass reproduction is not needed for intelligible speech; therefore, the design engineer may concentrate on making an efficient unit without deep bass.

However, a loudspeaker intended as a low frequency unit in a home installation requires smooth reproduction of deep bass. In order to achieve this bass response, the designer will sacrifice overall efficiency in favor of smooth, extended bass.

But both loudspeakers, properly housed, may actually have the same output level at extremely low frequencies!

This apparent contradiction can be explained by the fact that any low frequency loudspeaker's sound output will increase as the reproduced frequency increases, up to a point. The amount of magnetic energy, the stiffness of the cone suspension, the weight of the cone and other factors have been adjusted by the designer in such a way that the sound output of the home unit levels off at a relatively low frequency. The reinforcement speaker's energy output continues to increase well above that frequency. Both speakers have the same amount of deep bass output, but since the home unit's acoustical energy has been intentionally leveled off, there appears to be more bass from it than from the speaker designed for speech reinforcement.

The size and type of enclosure in which the loudspeaker is to be mounted will also affect the designer's adjustment of the variables in speaker design. Generally, a loudspeaker designed for a small box will be less efficient than one designed for a large box if equal low frequency response is required from both units.

Another significant efficiency factor is the size of the loudspeaker cone. If identical low frequency response characteristics are required from both a 380 mm (15 in) speaker and a 300 mm (12 in) speaker of similar construction, the 380 mm speaker will be more efficient than the 300 mm one, since the larger cone can couple with the air better and need not move as far as the smaller one to create equal sound pressure levels at the same low frequency. Note, however, that the 380 mm speaker requires a larger enclosure than the 300 mm for similar frequency response.

Power Handling Capacity

Even in the highest efficiency systems, less than 10% of the electrical power sent into the loudspeakers can be converted into sound power. The remaining electrical power is converted to heat. How well the loudspeaker can deal with this heat is one important factor in determining how much electrical power can be sent into the loudspeaker before it self-destructs.

Since the amplifier power is sent through the voice coil, the heat is generated in the coil. Given equal construction, a large voice coil will be able to handle more power than a small one, since the heat will be generated and therefore dissipated over a larger area. A large and heavy magnetic structure, in addition to providing greater efficiency than a small and light one, will be able to act more effectively than the smaller one as a "heat sink," accepting the heat from the voice coil and transferring it into the air.

If more power is sent into the speaker than it is designed to handle and the voice coil overheats, the coil itself can "burn up" and the wire can break, resulting in a dead speaker. Even if the wire in the coil doesn't break, the heat can blister and deform the support on which the voice coil is wound. This can cause the coil to become elliptical rather than perfectly round, and the coil may then touch the magnet's pole pieces, creating a rubbing action which eventually will short out the coil or completely jam its movement.

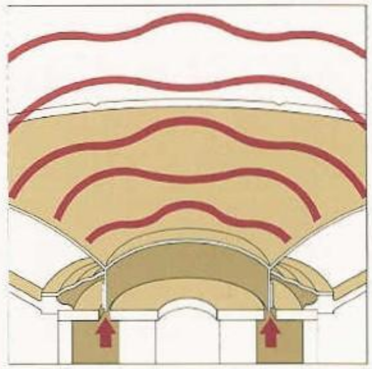
JBL voice coil assemblies can handle short-term transient peaks well above the rated power handling capacity, because these transients do not have enough duration to heat the voice coil beyond its limits. However, continuous excessive power, particularly when accompanied by amplifier distortion, may damage even the JBL speaker.

The other major aspect of power handling ratings is cone travel. There is a specific distance range over which loudspeaker cones are designed to move evenly. It is possible, however, to drive most cones beyond these limits. The result of excessive excursion is first of all distorted sound, since the cone cannot respond exactly to the electrical signals fed to it when operating at the mechanical limits of its travel. More importantly, the suspension of the cone may be damaged.

The cone is tied to the frame of the loudspeaker in two areas. The area where the voice coil is fastened to the cone has a suspension device called a "spider" attached between the cone and the frame. The spider allows the cone to move back and forth while keeping it centered in the magnetic gap. The outer edge of the cone is attached to the frame with a "surround" or "compliance," which may be a corrugated extension of the cone edge, a foam ring or some other material which is flexible, allowing the cone to move in and out while giving it lateral support. If the cone is forced to move beyond the design limits of the suspension, either or both the spider and the surround may be permanently distorted and the cone will no longer move correctly.

The pistons in high frequency compression drivers, called "diaphragms," are constructed differently. The edge of the diaphragm is tightly clamped to a ring, and a surround is formed out of the diaphragm material. Inside this flexible area, the voice coil is attached. Even though this type of surround has limited flexibility when compared to a cone surround, the amount of travel required is proportionally much less than in a cone loudspeaker, since the frequencies to be reproduced are much higher.

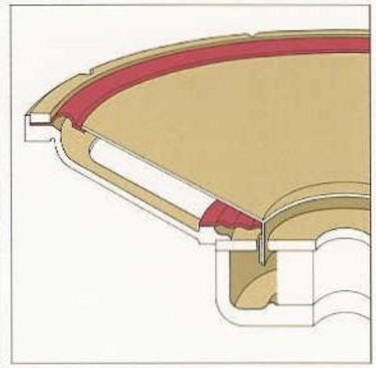
Compression drivers can be damaged by excessive power, with symptoms similar to cone speakers. Additionally, they can be mechanically damaged if frequencies too low for their design limits are sent into them,

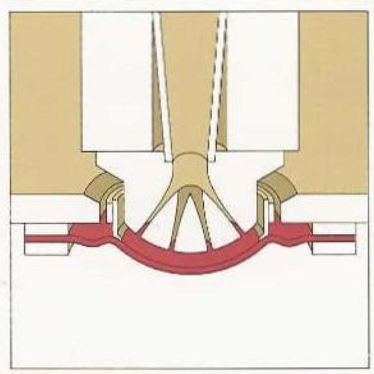


The result of excessive excursion is first of all distorted sound, since the cone cannot respond exactly to the electrical signals fed to it when operating at the mechanical limits of its travel. More importantly, the suspension of the cone may be damaged.

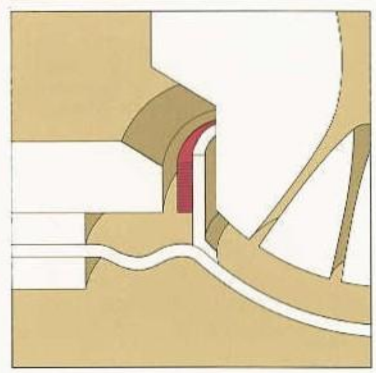
The area where the voice coil is fastened to the cone has a suspension device called a "spider" attached between the cone and the frame.

The outer edge of the cone is attached to the frame with a "surround" or "compliance," which may be a corrugated extension of the cone edge, a foam ring or some other material which is flexible, allowing the cone to move in and out while giving it lateral support.



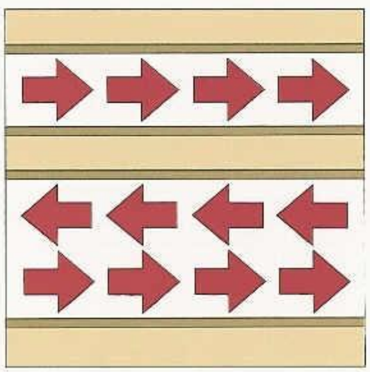


The pistons in high frequency compression drivers, called "diaphragms," are constructed differently. The edge of the diaphragm is tightly clamped to a ring, and a surround is formed out of the diaphragm material.

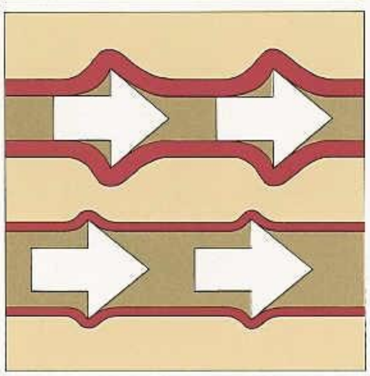


The voice coil support is attached just inside the flexible area formed into the diaphragm.

When one is dealing with electrical signals which flow in one direction only (direct current), such as from batteries, this property is called "resistance." When one has electrical signals flowing in two directions, back and forth (alternating current), such as in household power lines and audio circuits, this property is called "impedance." The unit of measurement for both impedance and resistance is the "ohm" (abbreviated "Ω").



Since a 16-ohm speaker system will impede the flow of current twice as much as an equivalent system with an 8-ohm impedance, less power will be available from most amplifiers for the 16-ohm system.



since at those frequencies they can be forced to move too far.

JBL cone and diaphragm suspensions are designed for excursions beyond their rated power handling capacity without causing permanent damage, as long as the lower frequency limits on high frequency transducers are observed. In home systems, amplifiers of greater output than the system is rated for can be successfully used without damaging the system, as long as reasonable volume levels are used. Since musical instrument loudspeakers are required to produce much higher sound levels in order to fill the much larger rooms in which they are generally used, the amplifier power should not exceed the loudspeaker power rating in order to avoid damage.

Putting fuses into the speaker lines is sometimes suggested for protection against speaker failure. JBL has reprints of an article on speaker fusing which discusses the pros and cons of this subject and tells how to go about it. Drop a note to the JBL Technical Services Department if you want a copy of this article ("Power Ratings of Loudspeaker Systems") or check with your JBL dealer who may also have this reprint available.

Impedance

Copper and aluminum are the materials commonly used to make the wire for voice coils. These metals are good conductors of electricity. Every conductor, however, impedes the flow of electrical current through it to some extent.

When one is dealing with electrical signals which flow in one direction only (direct current), such as from batteries, this property is called "resistance." When one has electrical signals flowing in two directions, back and forth (alternating current), such as in household power lines and audio circuits, this property is called "impedance." The unit of measurement for both impedance and resistance is the "ohm" (abbreviated "Ω").

Some devices may have the same resistance to direct current (abbreviated DC) as impedance to alternating current (abbreviated AC). Other devices, such as loudspeakers, will have different DC resistances and AC impedances, and the impedance can vary depending on the frequency of the AC.

The marked impedance of any dynamic loudspeaker, most commonly 4, 8 or 16 ohms, is really a nominal impedance only, and will vary not only according to the frequency of the incoming signal but can also be modified by the design of the loudspeaker enclosure.

Most amplifiers used in home and musical instrument applications today are transistorized units without transformers in the output circuits. The amount of power available from this type of amplifier will vary depending on the impedance of the loudspeaker system or systems connected to it. Since a 16-ohm speaker system will impede the flow of current twice as much as an equivalent system with an 8-ohm impedance, less power will be available from most amplifiers for the 16-ohm system. Similarly, a 4-ohm system will impede current flow half as much as an equivalent 8-ohm system, and more power may be drawn from most amplifiers with a 4-ohm load. This does not mean, however, that 4-ohm systems are better than 8-ohm systems, and that 2-ohm systems are still better!

As one connects lower load impedances to amplifier outputs, more current is drawn from the amplifiers, and this amount of current is limited by the amplifier design. If too much current is demanded from the amplifier, it will either stop working to protect its components or suffer component failure. Very few transistorized amplifiers are designed to work into load impedances of less than 4 ohms.

Further, it should be noted that the wires connecting the speakers to the amplifier are not perfect conductors; therefore, some power loss will always occur in these leads. The lower speaker system impedance is, the higher the percentage of power loss in the wiring will be, assuming the same wire size is used. A 4-ohm system should have wiring twice as heavy as an 8-ohm system over the same distance for equivalent wiring power loss.

JBL's recommendations for speaker hookup wire depend on the application, the distance and the system impedance, as shown in the chart. For most home applications, the average amount of power used is moderate. For musical instrument applications, the sound power requirements are much greater and the average amount of electrical power is also much higher.

Note that the smaller the wire gauge number is, the larger the wire size is. These figures are minimum recommendations. Larger wire may be used if desired, but the expense involved may not be reflected in acoustical improvements.

Multiple Speakers

A number of loudspeaker system designs include more than one loudspeaker covering the same frequency range. There are several considerations to be taken into account when putting together such a system.

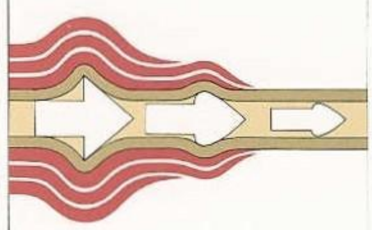
When multiple speakers are used, the pressure waves from the speakers will combine and interact. As the frequency of the signal increases, the pressure waves become shorter in length. Depending on the particular frequency and the arrangement and spacing of the speakers, the waves may reinforce or cancel each other. Uneven frequency response can result unless the designer has been careful.

For musical instrument and sound reinforcement applications, multiple speakers are sometimes put in line with each other in a "sound column" or "line array." When this kind of speaker array is placed vertically, the waves combine in such a way as to narrow the vertical angle of coverage at some distance from the system. High frequency units in these applications are sometimes arranged in an arc to broaden the dispersion of these frequencies, but care must be taken not to overlap the patterns or interference may result.

If multiple speakers are interconnected, the impedance and power handling of the system will be affected as well. The power handling capability of each individual speaker will be unchanged, but the total power capability of the combination will be greater than that of any individual speaker, assuming that the same frequency band goes to each of the multiple speakers.

Paralleling two identical speakers, as in the illustration, results in the impedance of the combination being

The wires connecting the speakers to the amplifier are not perfect conductors; therefore, some power loss will always occur in these leads.



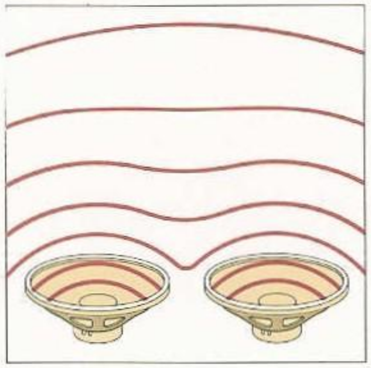
Wire Chart

Home High Fidelity Loudspeaker Systems

distance	impedance		
	4Ω	8Ω	16Ω
0-15 m (0-50 ft)	16 AWG	18 AWG	20 AWG
15-30 m (50-100 ft)	14 AWG	16 AWG	18 AWG
30-60 m (100-200 ft)	12 AWG	14 AWG	16 AWG

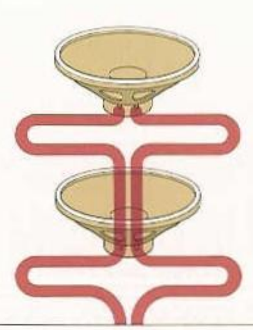
Musical Instrument Loudspeaker Systems

distance	impedance		
	4Ω	8Ω	16Ω
0-15 m (0-50 ft)	14 AWG	16 AWG	18 AWG
15-30 m (50-100 ft)	12 AWG	14 AWG	16 AWG
30-60 m (100-200 ft)	10 AWG	12 AWG	14 AWG

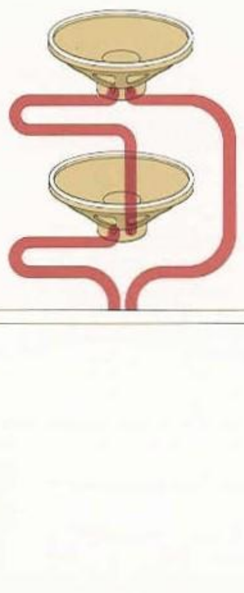


When multiple speakers are used, the pressure waves from the speakers will combine and interact.

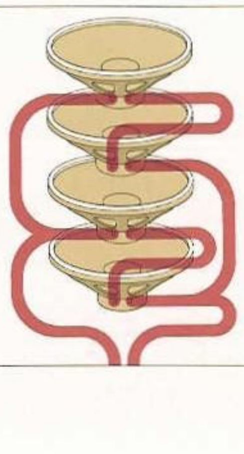
Paralleling two identical speakers results in the impedance of the combination being halved. If two 8-ohm speakers are connected in parallel, the impedance of the combination will be 4 ohms.



Connecting two identical speakers in series will result in a combined impedance double that of the individual speakers. Two 8-ohm speakers in series will have a combined impedance of 16 ohms.



By connecting four identical speakers in series-parallel, as shown in the illustration, the total system impedance can be the same as one speaker by itself. As an example, two 8-ohm speakers connected in series have a total impedance of 16 ohms. Paralleling this series pair with another identical series pair will result in two 16-ohm impedances being paralleled, with a combined result of 8 ohms. This is the impedance of each of the individual units.



halved. If two 8-ohm speakers are connected in parallel, the impedance of the combination will be 4 ohms.

Conversely, connecting two identical speakers in series, as in the illustration, will result in a combined impedance double that of the individual speakers. Two 8-ohm speakers in series will have a combined impedance of 16 ohms.

To find the impedance of a combination of any number of identical speakers connected in parallel, divide the impedance of one speaker by the number of speakers. For example, four identical 16-ohm speakers wired in parallel will have a total impedance of 4 ohms.

To find the impedance of a combination of any number of identical speakers connected in series, multiply the impedance of one speaker by the number of speakers. For example, four identical 8-ohm speakers connected in series will have a total impedance of 32 ohms.

By connecting four identical speakers in series-parallel, as shown in the illustration, the total system impedance can be the same as one speaker by itself. As an example, two 8-ohm speakers connected in series have a total impedance of 16 ohms. Paralleling this series pair with another identical series pair will result in two 16-ohm impedances being paralleled, with a combined result of 8 ohms. This is the impedance of each of the individual units.

Whether the speakers are connected in series, parallel or series-parallel, the total power used by the system will be divided up among the individual speakers. To find the total power handling capability of a system using any number of identical speakers, multiply the power handling capacity of one speaker by the number of speakers. A system with four identical speakers, each rated at 50 watts, will have a power handling capacity of 200 watts.

If dissimilar loudspeakers are interconnected, the rules given above may not apply, particularly if the impedances differ. Since the calculations for these systems are complex, they will not be discussed here. Elementary electronics textbooks contain the formulas for determining system impedances and power handling.

Remember that the impedance of the system will affect the amount of power available from most home and musical instrument amplifiers, as discussed earlier. A 4-ohm system will draw more power from most amplifiers than an 8-ohm system, and should use heavier interconnecting wire than the 8-ohm system.

Dividing Networks

In order to achieve a controlled transition between the low and high frequency transducers, a device called a "dividing network" (or "crossover network") is used. Most systems use "passive" dividing networks which are connected between the amplifier output and the individual speakers. "Active" dividing networks are sometimes used for bi-amplification in sound reinforcement and recording studio applications but will not be discussed here, since such systems require separate amplifiers for the low and high frequency loudspeakers and require special techniques to protect the high frequency transducers from accidental damage.

Passive dividing networks take the amplifier output and split the sound spectrum at a specified frequency, sending the low frequency portion to the low frequency loudspeaker and smoothly reducing the available energy at a controlled rate at and above the designated transition point. The high frequency portion is sent to the high frequency transducer, and frequencies at and below the transition point are similarly reduced. Most JBL dividing networks are designed to roll off the unwanted portions of the spectrum at a rate of 12 dB per octave, and both the high and low frequency outputs from the network are 3 dB down from full output at the rated transition point. Since both transducers are operating at 3 dB down from their normal outputs at the crossover frequency, their combined outputs work together to give smooth response through the transition.

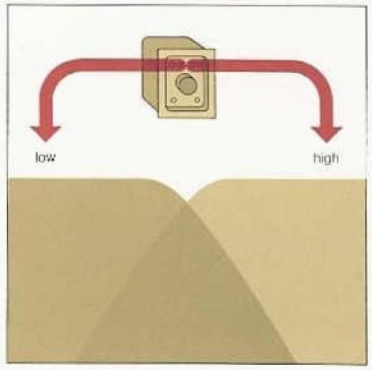
Since JBL high frequency transducers generally are more efficient than their companion low frequency loudspeakers, most JBL dividing networks have some means of reducing the amount of power sent to the high frequency unit, and these attenuators are adjustable either in steps or continuously. Reducing the amount of power sent to the high frequency units also helps protect them from damage due to power overload.

When selecting a passive dividing network, it is therefore important to observe the lower frequency limit of the high frequency speaker, the relative sensitivities of the low and high frequency speakers, the amount of attenuation built into the network, and the power handling capacities of the loudspeakers and the network.

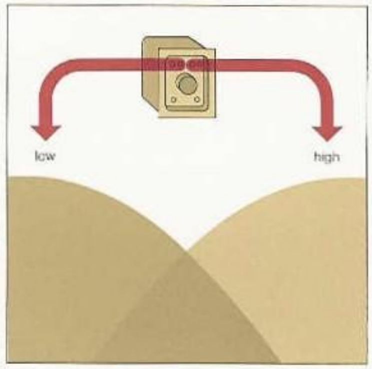
It is important to note that passive dividing networks are quite sensitive to the impedance of the speakers connected to them. If the wrong impedance speakers are used, the crossover frequency and the slope of the transition curve will be altered; as a result, the system will have uneven response in the crossover region.

JBL dealers who offer our component series loudspeakers can assist in the selection of component combinations. Also, the JBL Technical Services Department is available for advice and consultation.

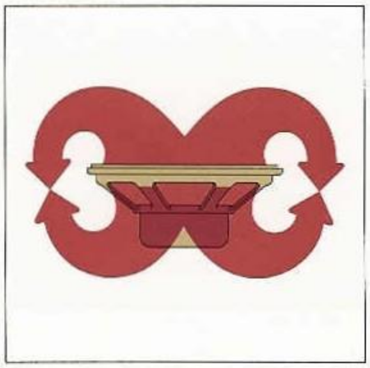
Passive dividing networks take the amplifier output and split the sound spectrum at a specified frequency, sending the low frequency portion to the low frequency loudspeaker and smoothly reducing the available energy at a controlled rate at and above the designated transition point. The high frequency portion is sent to the high frequency transducer, and frequencies at and below the transition point are similarly reduced.



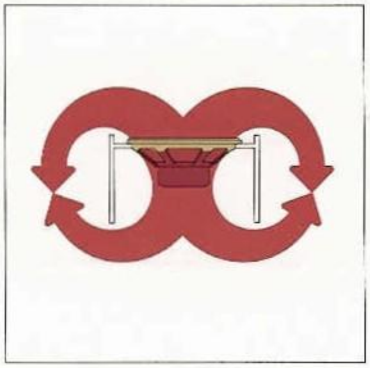
It is important to note that passive dividing networks are quite sensitive to the impedance of the speakers connected to them. If the wrong impedance speakers are used, the crossover frequency and the slope of the transition curve will be altered; as a result, the system will have uneven response in the crossover region.



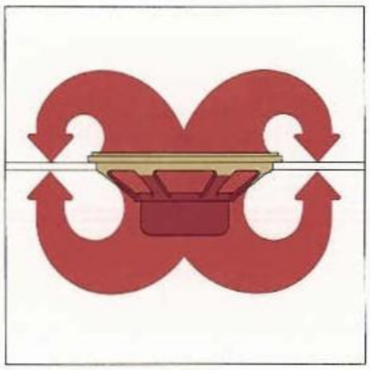
If a loudspeaker is not mounted in some kind of baffle, there is nothing to prevent air pressure waves being pushed by the front of the cone from combining with the equal and opposite waves being simultaneously created by the rear of the cone.



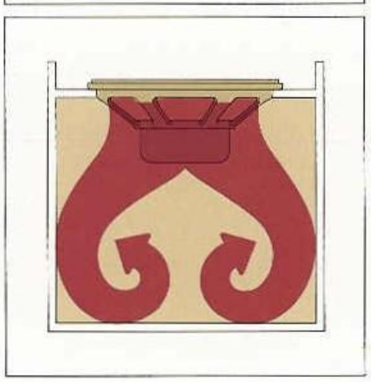
The acoustical effect of this open-back enclosure is to lower the frequency at which this cancellation becomes significant, but cancellation still occurs.



In order to avoid cancellation, the rear wave of the loudspeaker may be completely isolated from the front wave by keeping the back of the cone in a different space, mounting the loudspeaker in a wall or ceiling. This type of mounting is called an "infinite baffle."



Because structural installation is usually impractical, the speaker may instead be mounted in a large, closed box. This sealed enclosure is also called an infinite baffle.



Part 2

Understanding Enclosure Principles

As covered in Part One of this manual, a loudspeaker is a piston which moves air. The enclosure or box in which the loudspeaker is mounted should interact with the loudspeaker to increase its ability to move that air at the low end of the frequency spectrum.

The Unmounted Loudspeaker

If a loudspeaker is not mounted in some kind of baffle, there is nothing to prevent air pressure waves being pushed by the front of the cone from combining with the equal and opposite waves being simultaneously created by the rear of the cone. This combination, which becomes more pronounced as the frequency of cone movement goes lower, results in cancellation of the lower audio frequencies.

The Open Back Enclosure

Most early radios and packaged record players hid the actual loudspeaker, which did not fit into most interior decoration schemes, by mounting it in a cabinet, leaving the back of the cabinet open.

The acoustical effect of this open-back enclosure is to lower the frequency at which this cancellation becomes significant, but cancellation still occurs.

The Infinite Baffle

In order to avoid this cancellation, a logical further step is to completely isolate the rear wave of the loudspeaker from the front wave by keeping the back of the cone in a different space, mounting the loudspeaker in a wall or ceiling. This type of mounting is called an "infinite baffle."

Because structural installation is usually impractical, the speaker may instead be mounted in a large, closed box. This sealed enclosure is also called an infinite baffle.

However, if the internal volume of this sealed box is less than 420-460 litres (15-20 cubic feet) for a 380 mm (15 in) loudspeaker, or is correspondingly reduced for smaller loudspeakers, the cone will be pushing against the trapped air inside the box, and the amount of bass available from that speaker will be changed. The enclosure is interacting with the loudspeaker. As the box size is reduced, the effect on bass response becomes more pronounced.

The infinite baffle, open-back enclosure and free-air mounting have a number of disadvantages. The most significant problem from an acoustical standpoint is that the low frequencies receive no help from the enclosure, and in many cases may be reduced from what the speaker is capable of producing. From a mechanical standpoint, the three systems above leave the low frequency loudspeaker entirely dependent on its own mechanical construction for protection against excessive cone excursion. As discussed in Part One, excessive cone travel can result in distorted sound and damage to the cone suspension.

Acoustic Suspension Enclosures

If a low frequency loudspeaker is to be mounted in a small, sealed enclosure, the system designer can adjust the variable design parameters of the loudspeaker to take this enclosure into account. The suspension will be relatively loose, and the other variables will be such that when the speaker is installed in that small box, the bass response will be optimum for that speaker. This type of system is commonly known as "acoustic suspension" or "air suspension."

It should be stressed, however, that a loudspeaker should be designed for installation in a small, sealed box, or its potential low frequency response will be drastically reduced and low frequency distortion will increase when installed in such an enclosure. Even if the speaker is designed for an acoustic suspension enclosure, putting it in a box which is smaller than optimum will result in a "bump" in the low frequency area. This may give greater apparent mid-bass response but less relative low bass.

Horn Loaded Enclosures

The earliest loudspeakers were designed in the time when large amounts of amplifier power were difficult to achieve due to equipment limitations. Consequently, a speaker system which was to be used in a large space, such as a theater, had to be housed in an enclosure which would most efficiently convert the limited electrical power available from the amplifier into acoustical power.

In their earliest forms, these highly efficient enclosure designs resembled giant french horns, which is one reason they became known as "horn-loaded enclosures."

Among the disadvantages of this type of enclosure are that in order to accurately reproduce low frequencies, the horn must be extremely large. For example, full output to 40 Hz (the bottom "E" on a bass) would require a horn mouth area of 5.2 square metres (56.25 square feet) and an exponentially flaring horn length of 7.6 metres (25 feet). Attempts to compress the length of the horn by folding it back and forth may create irregularities in lower midrange reproduction besides making the enclosure quite difficult to build.

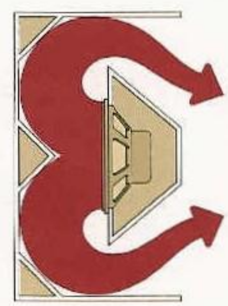
JBL has manufactured a number of horn designs for both home and professional use, but the only JBL horn-loaded enclosure currently available for home use is the spectacular Paragon. The professional horn-loaded enclosures made by JBL are designed for sound reinforcement purposes and are too large or do not have enough low bass response for pleasing home listening.

Bass Reflex Enclosures

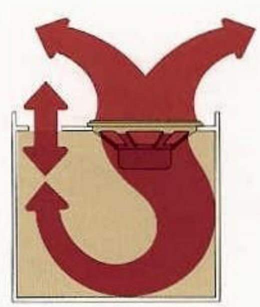
Finally, we come to the bass reflex enclosure, which we believe represents the best compromise between size, bass response and efficiency.

The bass reflex is a cabinet which is sealed except for a vent of specific dimensions. The vent tunes the enclosure so that the air inside the box reinforces the bass response of the loudspeaker instead of interfering with it. Since the cone has the benefit of this bass reinforcement, its travel distance at these low frequencies can be reduced, lowering distortion in bass reproduction. Additionally, the lessened cone travel means that the cone suspension is protected from some of the more

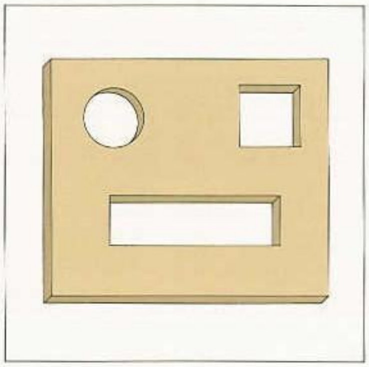
If a low frequency loudspeaker is to be mounted in a small, sealed enclosure, the system designer can adjust the variable design parameters of the loudspeaker to take this enclosure into account. The suspension will be relatively loose, and the other variables will be such that when the speaker is installed in that small box, the bass response will be optimum. This type of system is commonly known as "acoustic suspension" or "air suspension."



Horn-loaded systems convert electrical power into acoustical power with high efficiency. However, they must be extremely large to provide deep bass response, and folding the sound path in the horn may create irregularities in lower midrange reproduction and make the enclosure difficult to build.

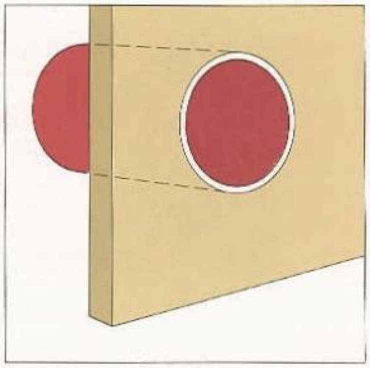


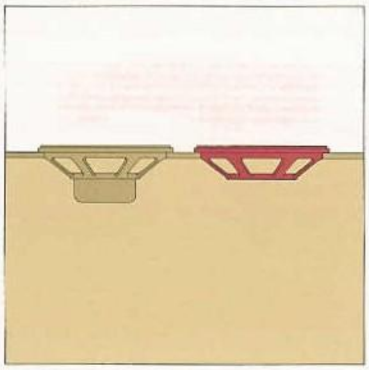
The bass reflex is a cabinet which is sealed except for a vent of specific dimensions. The vent tunes the enclosure so that the air inside the box reinforces the bass response of the loudspeaker instead of interfering with it.



The shape of the vent is not critical. It may be a simple round, square or rectangular port.

The port may have a duct or tunnel attached to it and it may be divided into two or more ports if a single port is too large for convenient enclosure design and construction.





A passive radiator, which looks like a loudspeaker without a magnet or voice coil, can be used as a substitute for a port.

If the frequency to which the port or passive radiator is tuned is too high, a "bump" in low frequency response will occur. If the tuning frequency is too low, bass response will be deficient. In both cases, the loudspeaker system is not performing at its optimum level.

extreme low frequency disturbances which might damage it.

A passive radiator, which looks like a loudspeaker without a magnet or voice coil, can be used as a vent.

The passive radiator is a mechanical substitute for the air in a port. It is free to vibrate back and forth, just as the air in a port is, and its moving mass and structure are chosen to match the particular loudspeaker and enclosure, just as the size and type of a port is. In fact, the passive radiator concept was developed as a mechanical model of a port to aid in scientific investigation of the properties of a vented box.

It is important to remember that the loudspeaker, the port and the passive radiator all basically operate in the same fashion. Air is vibrated back and forth by these devices creating pressure waves, and the port or the passive radiator's "drone cone" is the means for coupling the air inside the enclosure to the listening room.

A ported enclosure is tuned to a particular frequency by adjusting the amount of air in the port. If the port is a simple hole, the size of the hole is changed. If the port is ducted, either or both the size and the length of the ducted port can be altered.

An enclosure with a passive radiator installed is tuned by attaching or removing weights on the rear of the drone cone.

If the frequency to which the port or passive radiator is tuned is too high, a "bump" in low frequency response will occur. If the tuning frequency is too low, bass response will be deficient. In both cases, the loudspeaker system is not performing at its optimum level.

Further, low frequency loudspeakers designed for reflex enclosures are intended for installation in cabinets which have internal volumes within a specific range. Installing a low frequency loudspeaker in a reflex enclosure which is too small for it will result in deficient bass response, and it will not be possible to tune the enclosure properly.

All JBL loudspeakers have been pre-engineered for optimum reflex tuning in specific internal volumes. If other low frequency loudspeakers are used, a simple procedure for tuning the enclosure can be found in the Appendix. It is necessary, however, to know the recommended enclosure volume and optimum tuning frequency, which should be obtainable from the manufacturer of that particular speaker. It is not possible for JBL to make recommendations for speakers from other manufacturers.

There are many additional loudspeaker and enclosure designs which have been marketed and will continue to come from the fertile minds of designers. Most of these designs purport to solve problems which have preoccupied loudspeaker engineers since the beginning of the audio industry. On test, most of these designs fall by the wayside, because their advocates have not succeeded in repealing the laws of physics.

Since its founding, JBL has engaged in constant research into the mechanics of sound reproduction. Despite this accumulation of knowledge and expertise, we have not yet found any designs that offer significant advantages in faithfulness of sound reproduction over those which we currently offer.

Part 3

High Fidelity Systems For The Home

JBL is one of a small number of loudspeaker manufacturers who offer a broad line of components for the assembly of custom high fidelity loudspeaker systems. The selection of components is a complex process, involving the balancing of component efficiencies, power handling, impedances, crossover frequencies and other factors.

Component selection should begin with the choice of low frequency loudspeaker and enclosure. There is a specific range of enclosure sizes in which a particular low frequency loudspeaker will perform properly. In general, a low frequency loudspeaker designed for a large enclosure will result in greater efficiency than a low frequency unit designed for a small enclosure. However, if space limitations preclude the use of a large enclosure the smaller loudspeaker will give deep and smooth response, with efficiency being the only difference.

Once the enclosure and low frequency loudspeaker have been selected, the high frequency units can be chosen to complement the low frequency section. The plans in this package cover three different enclosure sizes, and there are separate baffle board plans to cover various combinations of components.

Some of the larger high frequency units may not fit inside the enclosures, and will have to be installed outside of the boxes. In such cases, these units can be concealed by constructing a shell to fit around either the high frequency section or the entire enclosure.

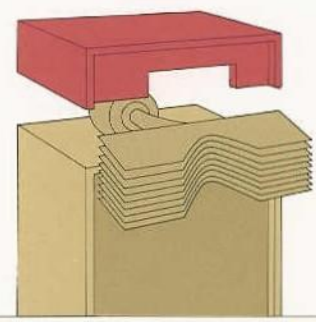
Extended range loudspeakers are not full range units. The frequency response of an extended range speaker is engineered to be as broad as possible, but any extended range loudspeaker will have less bandwidth than a matched set of low and high frequency transducers of equivalent quality.

However, an extended range loudspeaker is less expensive than separate low and high frequency units of equivalent quality and can sound better than separate units of lesser quality.

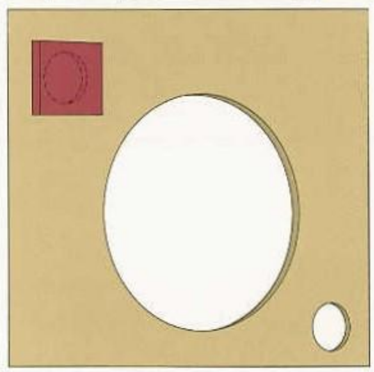
If it is desired to build a system in stages, starting with a single loudspeaker and adding a high frequency driver later, we recommend starting with an extended range loudspeaker, since the high frequency response from a speaker designed for low frequencies only will be unsatisfactory. The enclosure's baffle board may be cut for future speakers, and the mounting holes may be blocked with a board or plate installed on the inside of the baffle until the additional components are installed.

Optimum results will be achieved from our home hi-fi speakers with the enclosures built from the plans in this package. There may be a need, however, to use an existing enclosure of differing size or to build a box to fit a particular space requirement. Satisfactory results may be obtained from enclosures of other internal volumes if the enclosures are built according to the mechanical standards detailed in Part Five of this manual and are ported according to our recommendations. Note, however, that the porting chart included

Some of the larger high frequency units may not fit inside the enclosures, and will have to be installed outside of the boxes. In such cases, these units can be concealed by constructing a shell to fit around either the high frequency section or the entire enclosure.



The enclosure's baffle board may be cut for future speakers, and the mounting holes may be blocked with a board or plate installed on the inside of the baffle until the additional components are installed.



gives no recommendations for some combinations of loudspeakers and enclosure sizes, because these combinations will not give satisfactory results.

JBL dealers who are suppliers of our custom components can assist in the selection of those component combinations which will best meet the requirements of a particular home installation. In addition, the JBL Technical Services Department is available to answer questions pertaining to the use of our products.

We cannot make recommendations for systems involving components from other manufacturers, because any such system must be tested to confirm that the components will work together properly, and the possible combinations are virtually limitless.

The enclosure drawings in this package may be used to build cabinets for other manufacturers' loudspeakers, but the baffle layouts and porting recommendations for JBL loudspeakers may not apply. If the manufacturer of another loudspeaker supplies porting recommendations, those should be followed. If porting recommendations are not available, it is necessary to obtain the proper system tuning frequency from the manufacturer of that speaker. The port should then be tuned according to the procedure outlined in the Appendix of this manual.

If neither porting recommendations nor system tuning frequencies are available, a great deal of experimentation will be required to determine the tuning which will result in the best bass response and safest loading for that loudspeaker, as discussed in Part 2.

Part 4

Musical Instrument Loudspeaker Systems

JBL K Series Musical Instrument Loudspeakers are designed for powerful, efficient projection of amplified electric instruments and voices. The K Series loudspeakers are improved versions of the earlier F Series units, with increased clarity and power handling capacity. The enclosure recommendations for the K Series loudspeakers are the same as for the earlier F Series.

We do not recommend the use of JBL musical instrument loudspeakers for the reproduction of recorded music in the home. These speakers have been optimized for direct reproduction of amplified electric instruments and voices and may depart significantly from those acoustical parameters established for the playback of fine recorded music.

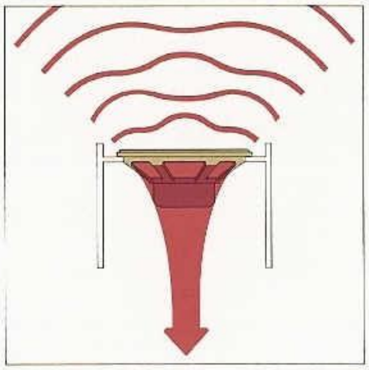
Optimum results will be achieved from our musical instrument speakers with the enclosures built from our plans. There may be a need, however, to use an existing enclosure of differing size or to build a box to fit a particular space requirement. Satisfactory results may be obtained from enclosures of other internal volumes if the enclosures are built according to the mechanical standards detailed in the construction section and are ported according to our recommendations.

We do not recommend using K Series loudspeakers in open-back enclosures, such as those supplied with other manufacturers' amplifiers. The use of a K Series unit in an open-back enclosure can result in severe damage to the loudspeaker, since the cone assembly is designed specifically for a properly tuned reflex enclosure and excessive cone excursion can more easily occur with an improper enclosure, as discussed in Part Two.

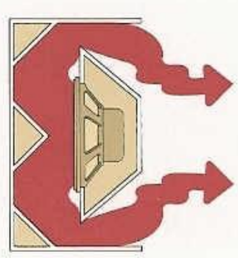
Some musicians, however, prefer the sound character of an open-back box. If a K Series loudspeaker is installed in an open-back enclosure, the maximum power applied to the speaker should not exceed 50% of its continuous sine wave rating. For example, a K Series loudspeaker which is rated at 125 watts continuous sine wave, should not have more than approximately 60 watts continuous sine wave applied to it when mounted in an open-back box.

As discussed in the second section of this manual, horn-loaded enclosures are difficult to build and must be extremely large in order to give full low frequency performance. If a K Series speaker is installed in a horn which is too small for proper cone loading, strong low frequency information below the horn cutoff frequency can cause the cone to behave as if it were not in an enclosure at all, with consequent likelihood of cone destruction. Remember also that folded horn designs can give uneven frequency response in the low midrange area.

If musical instrument loudspeakers from other manufacturers are used, the recommendations for optimum size and porting of the JBL K Series may not apply. If the manufacturer of that loudspeaker supplies porting recommendations, those recommendations should be followed. If porting recommendations are not available,

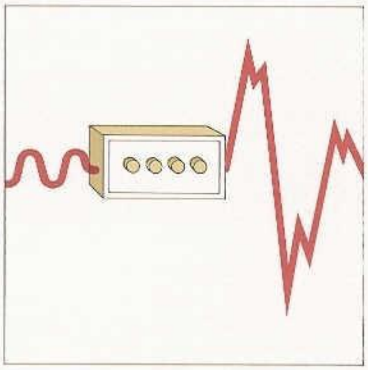


The use of a K Series unit in an open-back enclosure can result in severe damage to the loudspeaker, since the cone assembly is designed specifically for a properly tuned reflex enclosure and excessive cone excursion can more easily occur with an improper enclosure.

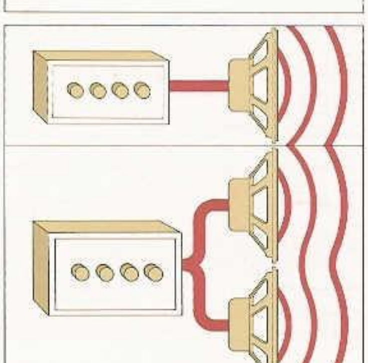


Horn-loaded enclosures are difficult to build and must be extremely large in order to give full low frequency performance. If a K Series speaker is installed in a horn which is too small for proper cone loading, strong low frequency information below the horn cutoff frequency can cause the cone to behave as if it were not in an enclosure at all, with consequent likelihood of cone destruction. Remember also that folded horn designs can give uneven frequency response in the low midrange area.

Because an amplifier is rated at a specific power level, it does not necessarily follow that it cannot put out more than that amount of power. An amplifier can be overdriven and put out distorted signals well in excess of its rated power output. The loudspeaker can be permanently damaged if the distorted signal from the amplifier exceeds the power level for which the speaker is designed.



If more sound power is required than can be achieved with one loudspeaker working at maximum rated power, additional loudspeakers can be added so that more power may be applied to the system.



it is necessary to obtain the proper system tuning frequency from the manufacturer of that speaker. The port should then be tuned according to the procedure outlined in the Appendix of this manual.

JBL cannot make recommendations for other manufacturers' products. If neither porting recommendations nor system tuning frequencies are available, a great deal of experimentation will be required to determine the tuning which will result in the best bass response and safest loading for that loudspeaker.

When building an enclosure to house more than one musical instrument loudspeaker of the same model, the enclosure volume and port area should be approximately double that for one speaker.

The baffle plans in this package show a cutout for the JBL 2901 High Frequency Power Pack, consisting of a high frequency driver mounted on a horn/lens assembly and a network which crosses over at 3 kHz. The network is fitted with a continuously variable attenuation control for high frequency balance. Musicians who prefer extremely bright sound from their instruments use the 2901 to add this "edge" to their systems. If the addition of the 2901 is not planned, the cutout may be omitted. If it is planned to add a 2901 at some later date, the baffle may be precut for this unit, and the hole may be blocked with a plate mounted on the inside of the enclosure.

A few additional words on the power handling capacity of musical instrument loudspeakers are in order. Because an amplifier is rated at a specific power level, it does not necessarily follow that it cannot put out more than that amount of power. An amplifier can be overdriven and put out distorted signals well in excess of its rated power output. The loudspeaker can be permanently damaged if the distorted signal from the amplifier exceeds the power level for which the speaker is designed.

For this reason, we strongly recommend that pushing an amplifier into overload distortion be avoided. Also, "fuzz" devices should be used with caution, since it is difficult to determine whether or not an amplifier is overloading when a pre-distorted "fuzz" tone is fed into it.

Further, the amount of power available from the amplifier is not necessarily related to the setting of the volume control, which only sets the sensitivity of the amplifier. Depending on the amount of signal fed in, it is possible to drive an amplifier into overload distortion with the volume control set at "9 o'clock" (¼ of the way up) or even lower.

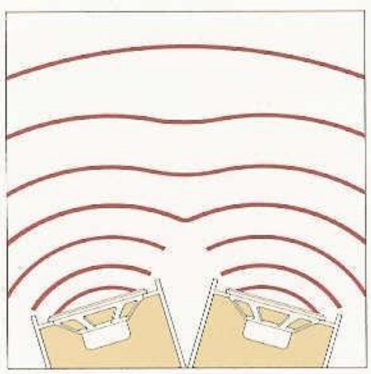
If more sound power is required than can be achieved with one loudspeaker working at maximum rated power, additional loudspeakers can be added so that more power may be applied to the system. Part One of this manual has a discussion of impedance versus power output from transistorized amplifiers without output transformers. These considerations should be noted when using this type of amplifier with multiple speakers.

There are a number of musical instrument amplifiers, however, which use vacuum tubes instead of transistors and consequently are equipped with output transformers. The output from this type of amplifier does not increase with lowered load impedances. Also, a tube amplifier is designed to work into specific load impedances, and its output transformer has one or more connections for matching up with these specific impedances. A tube unit must operate into the impedances intended for it.

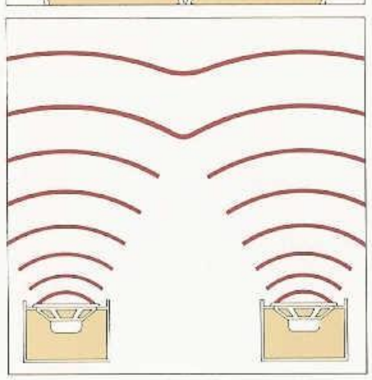
When using multiple speakers, it is generally desirable to stack the speakers on top of each other, since broad horizontal sound dispersion is usually required and vertical dispersion need not be as great. If speakers are placed side by side, horizontal dispersion will be narrowed and vertical dispersion will be broadened. If the speakers are in separate cabinets, however, they may be "splayed," or aimed in an arc, to broaden dispersion. Simultaneous stacking and splaying of loudspeakers will result in the broadest horizontal and vertical dispersion.

If multiple speakers are used for a single sound channel and the speakers are separated by twenty feet or more, the coverage areas of each speaker system should overlap as little as possible for minimum acoustical interference between the speakers.

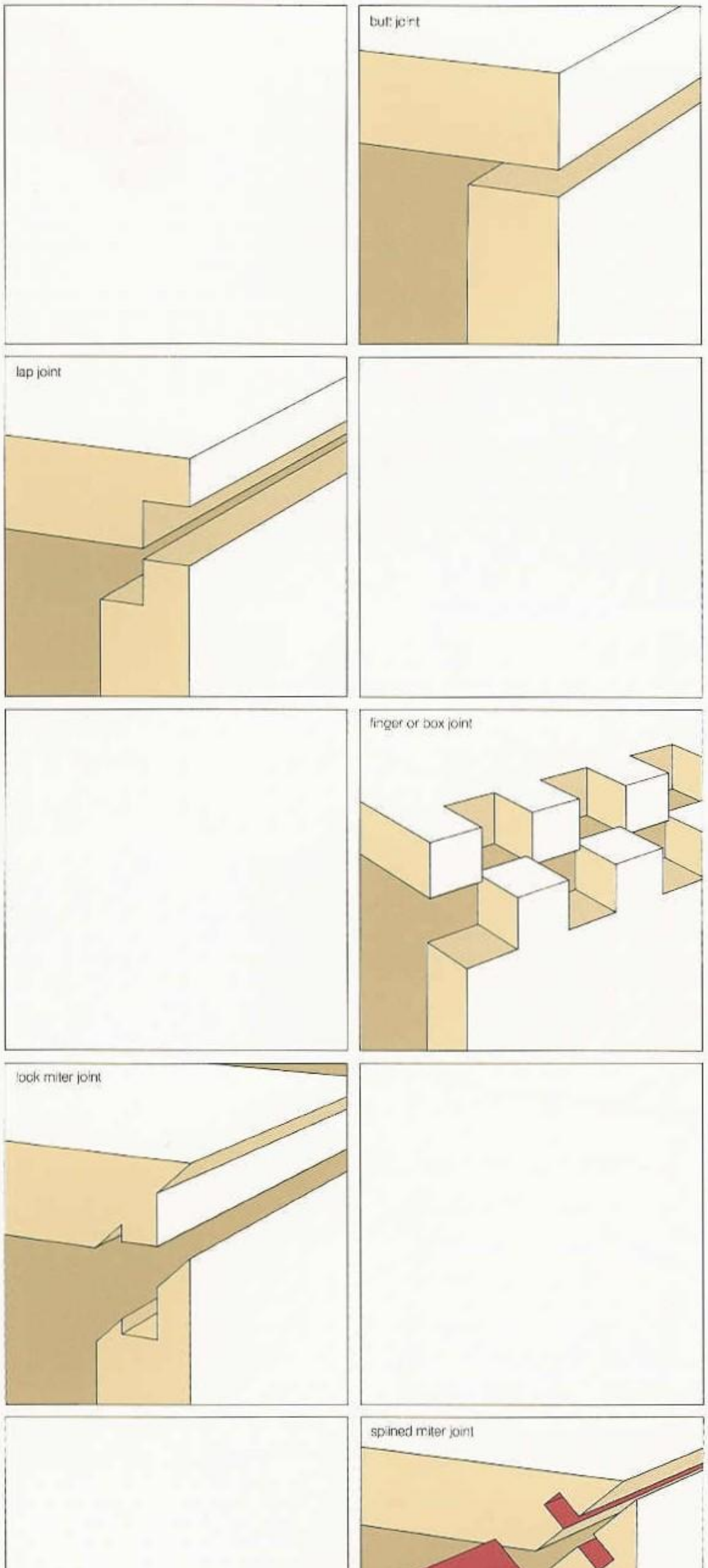
Remember that doubling the amount of power fed to the loudspeaker will result in only 3 dB of increased output, which is far from being twice as loud as the original sound. To double the loudness (increase the output by approximately 10 dB), ten times the power is required at the speaker terminals.



If the speakers are in separate cabinets, they may be "splayed," or aimed in an arc to broaden dispersion.



If multiple speakers are used for a single sound channel and the speakers are separated by twenty feet or more, the coverage areas of each speaker system should overlap as little as possible for minimum acoustical interference between the speakers.



Part 5

Enclosure Construction

Once the size and type of enclosure have been determined and the loudspeakers have been chosen, the enclosure can be built. It should be solidly constructed of 19 mm (¾ in) plywood or particle board (sometimes called "chipboard"). We do not recommend the use of solid hardwood for enclosures, since it is more susceptible to warping and generally does not provide adequate strength. If the enclosure is to be installed in a home, veneered material may be chosen to suit the decor requirements. Musical instrument speaker cabinets often use plastic sheet or film materials to cover the enclosure, so these cabinets need not use veneered wood.

It is generally preferable to mount loudspeakers on the front of the baffle panel. This makes it possible to have a more rigid cabinet structure and avoids acoustical problems caused by diffraction effects from the short tunnel formed by the cutout in the baffle when the loudspeaker is rear mounted. A cabinet designed for front-mounted speakers need not have a removable back, so construction is simplified and all panels can be installed with glue joints. If the speakers are to be mounted from the rear, the back panel of the enclosure must be removable and care must be taken to insure that it forms an airtight seal when installed. The plans in this package are laid out for front-mounted loudspeakers.

If enclosures other than those in our plans are to be built, no dimension should be more than three times any other. For example, an enclosure measuring 300 mm x 600 mm x 1200 mm (1 x 2 x 4 feet) would be undesirable because the 1200 mm dimension is four times greater than the 300 mm dimension.

The plans in this package give exact dimensions for each panel in the enclosure and for any cutouts to be made in the panels for mounting JBL loudspeakers and dividing networks. As mentioned before, if a system is being built with planned future expansion capability, it is generally easier to make cutouts for all components to be installed and to seal the unused holes with wooden plates mounted on the interior surfaces of the cabinet. By doing this in the initial construction stages rather than at a later date, much inconvenience and possible finish damage can be avoided.

Since JBL factory-built enclosures are assembled from complete matched sets of basic parts, we cannot provide precut panels, hardware, port tubes or component parts on a special order basis. Items such as T-nuts, screws and cabinet hardware can be purchased from hardware or builders' supply outlets.

Joints

All enclosure joints must be true and tight, since an accumulation of small air leaks can create whistles and hisses and may degrade the low frequency performance of the system. Lock-mitered joints are ideal if the necessary milling machinery is available. Some lumber yards will cut panels to specification and miter the panel edges for joining. If lock mitering is not possible, use a cleat or glue block running the length of each miter, lap or butt joint.

To insure an airtight seal, a liberal amount of good quality water resistant glue should be applied to all joints and to the contact areas between the cleats and adjacent panel surfaces. In addition, cleats should be screwed to both panels at 125 mm (5 in) intervals.

Bracing

If the internal volume of the cabinet is greater than 56 litres (2 cubic feet), all panels should be stiffened by braces placed on edge at approximately 250 mm (10 in) intervals horizontally or vertically. The braces should be glued and screwed in the same manner as the cleats at the joints. In addition, the ends of front-to-rear braces should be secured by screws through the baffle and back panels of the enclosure. This bracing will damp out any tendency for the enclosure panels to vibrate in sympathy with the loudspeaker, coloring the low frequency response of the system.

Once the enclosure is assembled, the bracing can be tested by striking various parts of the cabinet with a rubber mallet. A well-braced enclosure will emit a dull thud. Ringing or vibrations indicate the need for additional bracing. A further test for bracing is to play heavy bass material through the system after it has been assembled (and tuned, if required). Check each surface of the enclosure by running a hand over it, looking for any areas which vibrate excessively. Such areas should have additional bracing installed.

Baffle Panel

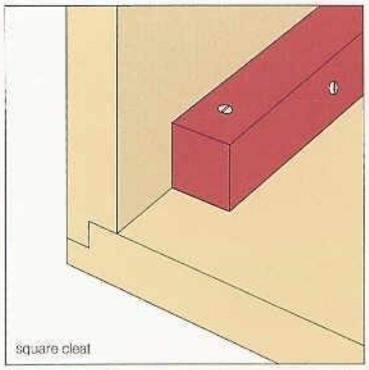
The baffle panel must be flat and true, because when a loudspeaker is installed on a warped surface, tightening the mounting screws can warp the speaker frame and cause the voice coil to rub. JBL speakers use cast frames, which are less subject to this problem than the stamped frames used by some manufacturers; nonetheless, warped baffles should be avoided.

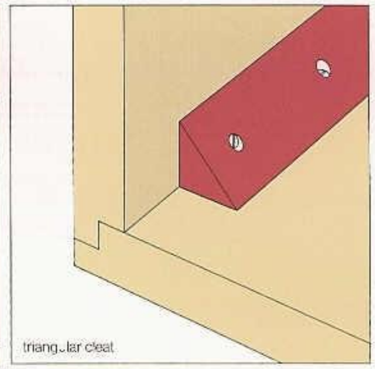
Interior Padding

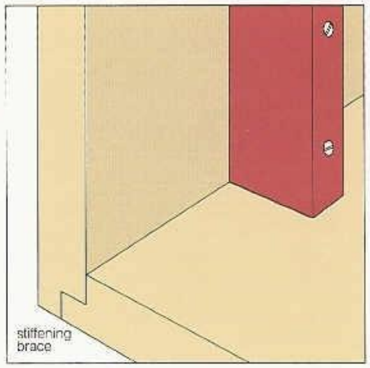
The interior surfaces of the enclosure, except for the baffle panel, should be lined with soft fluffy absorptive material. This can be attached with spots of glue, upholstery tacks or staples. The absorptive padding eliminates interior midrange reflections which might introduce coloration into the system's sound. Ordinary 25 mm (1 in) thick acoustic fiberglass is excellent, although other absorptive materials such as Kimsul, Tufflex or felt rug padding will serve equally well. These materials may be purchased from hi-fi dealers or firms specializing in insulating materials.

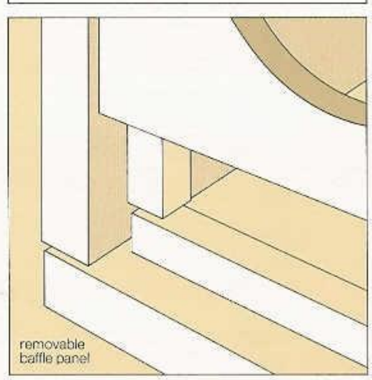
We do not recommend Celotex, foam rubber, styrofoam, rock wool, acoustic tile, cork, cotton, rubberized rug padding, Kapok or Tectum, since these materials are insufficiently absorptive, too fibrous, subject to long-term deterioration or are affected by a combination of these problems.

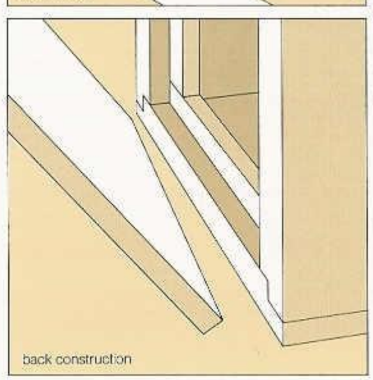
In some cases, however, coloration may be desirable in a musical instrument loudspeaker system. The midrange character of such a speaker can be varied to some extent by changing the amount of padding inside the enclosure. Since this will affect the overall sound of the system, each musician should experimentally de-



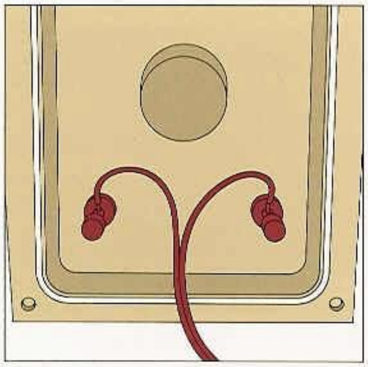




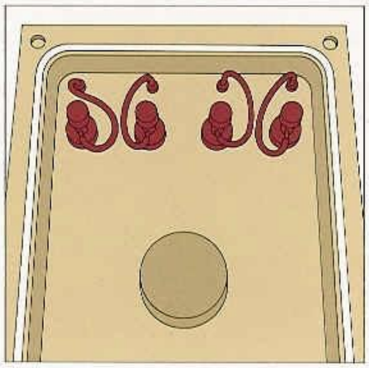


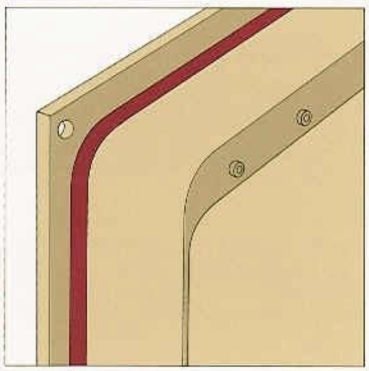


The leads from the amplifier connect to the bottom terminals on the network.



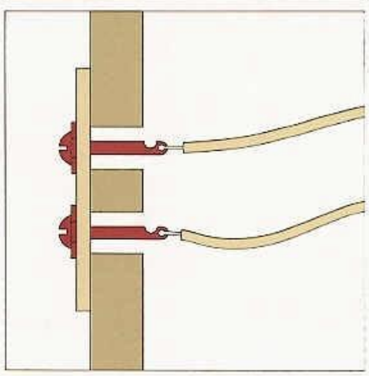
The leads from the network to the speakers can be routed through the holes provided in the network mounting plate just above the top terminals.





Be sure that the tubular vinyl gasket is in place, so that air leaks around the mounting flange do not occur.

A home system using an extended range speaker without a dividing network should have a screw terminal strip mounted on the exterior of the enclosure back panel, with the solder lugs extending through holes drilled into the back.



termine the amount of enclosure padding needed to achieve the desired instrument sound.

Connections

It is generally desirable to provide for system connections before the exterior of the enclosure is finished to avoid possible damage to the finish. The individual components, however, should be mounted and wired after the finishing process is complete.

If you are not using JBL loudspeakers and the loudspeaker manufacturer supplies a tuning frequency instead of specific porting recommendations, all components should be temporarily mounted and wired and the tuning procedure described in the Appendix completed before proceeding with finishing in order to avoid the possibility of finish damage. The components should be removed once the enclosure is tuned so that the finishing may be done without special precautions.

Connecting The Home System

A home system employing a JBL dividing network will have all system connections made to the network, and no additional holes need be made. The leads from the amplifier connect to the bottom terminals on the network, and the leads from the network to the speakers can be routed through the holes provided in the network mounting plate just above the top terminals. Connect the wires according to the instructions provided with the network. Be sure that the tubular white vinyl gasket is in place, so that air leaks around the mounting flange do not occur.

A home system using an extended range speaker without a dividing network should have a screw terminal strip mounted on the exterior of the enclosure back panel, with the solder lugs extending through holes drilled into the back. It may be preferable to use a screw terminal strip with barriers between the terminals, to lessen the possibility of accidentally shorting the amplifier leads together. In either case, care should be taken to avoid air leaks from the holes provided for the solder lugs.

It generally will be easiest to solder speaker connection wires of adequate length and gauge to the lugs before mounting the terminal strip. Then push the wires through the holes and mount the strip with wood screws.

Connecting The Musical Instrument System

Musical instrument speaker enclosures most often use ¼" phone jacks for connections, permitting the matching plugs to be inserted and removed quickly. However, the shanks on these jacks usually are not long enough for mounting through 19 mm (¾ in) material, and the compressibility of wood or particle board makes firm installation difficult.

When using a ¼" phone jack or other connector designed for quick installation and removal of the mating plug, the jack should be mounted on a metal plate. Cut a neat hole in the back of the enclosure for the plate. The hole should be smaller than the plate but larger than the connector. If the cutout is neat, the plate may be mounted on the inside of the enclosure after finishing. The resulting recessing of the connector will help to protect it from shipping damage. Alternatively, the plate may be mounted on the exterior after finishing. In either case, care should be taken to insure that no air leaks around the plate will occur.

When multiple speaker enclosures are to be connected to a single amplifier, it is sometimes more convenient to run wiring from the amplifier to one system, and then to interconnect the systems by running wires between the systems rather than from the amplifier to each system separately. An additional "loop-through" jack can be added in parallel to the original jack on each system to allow this method of hookup, taking total system impedance into account. If this is done and ¼" jacks are being used, spring-loaded hinge covers such as Switchcraft's Series 500 should be installed on the jacks so that no air can leak through an unused jack opening.

One further nicety may be desirable. Loudspeaker cones can bounce around quite a bit during transport, and cone damage can sometimes occur because of this. However, shorting the voice coils during shipment will tend to damp out cone movement, lessening the possibility of damage.

If loop-through jacks are not used, a single closed-circuit jack (Switchcraft 12-A or equivalent) wired as shown in the diagram will automatically short out the speaker voice coils when no plug is inserted.

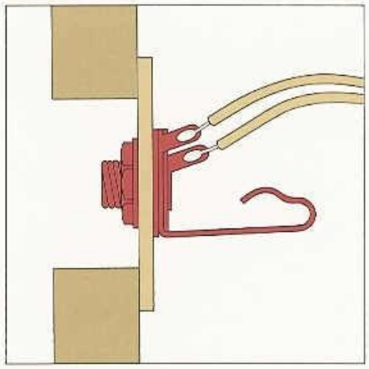
If, however, loop-through jacks are used, two different types of ¼" jacks should be used: one ordinary two-circuit jack (Switchcraft 11 or equivalent) and one "transfer circuit" jack (Switchcraft 13A or equivalent). These should be wired as in the diagram.

When using the latter hookup scheme, it is extremely important to label the jacks properly. The transfer circuit jack should be labelled "Input" and the standard jack should be labelled "To External Speaker," or words to that effect. If the amplifier is connected to the external speaker jack and no plug is inserted in the input jack, the speaker will not operate and the amplifier will not be connected to anything, which could cause damage to some amplifiers. If, however, plugs are inserted in both jacks, the amplifier and external speaker may be connected to either of the jacks.

Loudspeaker Mounting

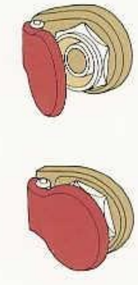
JBL loudspeakers, horns, lenses and compression drivers are supplied with mounting hardware, which can be found underneath the packing material in the shipping cartons. Units designed for front mounting are supplied with T-nuts and machine screws, which allow the loudspeakers to be removed and reinstalled any number of times without damaging the baffle board. A second, longer set of hardware is supplied with the units that can be rear mounted.

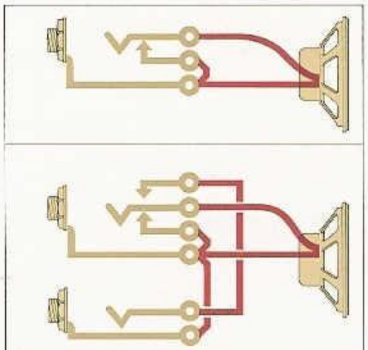
If it is impractical to use the machine screws and T-nuts, the loudspeaker can be mounted with wood screws. Use #10 wood screws for 200 , 250 , and 350 mm (8 , 10 , and 14 in) units and #14 wood screws for 300 , 380 , and 450 mm (12 , 15 , and 18 in) units. The K Series 450 mm (18 in) bass speaker is extremely heavy, and it should be mounted with eight screws. All other JBL speakers may be mounted with four screws



When using a ¼" phone jack or other connector designed for quick installation and removal of the mating plug, the jack should be mounted on a metal plate.

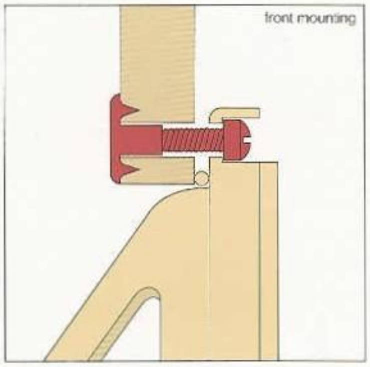
An additional "loop-through" jack can be added in parallel to the original jack on each system to allow this method of hookup, taking total system impedance into account. If this is done and ¼" jacks are being used, spring-loaded hinge covers such as Switchcraft's Series 500 should be installed on the jacks so that no air can leak through an unused jack opening.

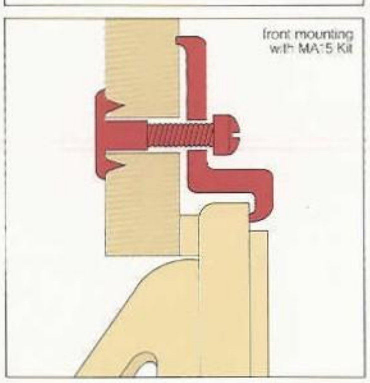




If loop-through jacks are not used, a single closed-circuit jack (Switchcraft 12-A or equivalent) wired as shown in the diagram will automatically short out the speaker voice coils when no plug is inserted.

If, however, loop-through jacks are used, two different types of ¼" jacks should be used: one ordinary two-circuit jack (Switchcraft 11 or equivalent) and one "transfer circuit" jack (Switchcraft 13A or equivalent). These should be wired as in the diagram.





spaced at 90° intervals around the frame

Front mounting of JBL 380 mm (15 in) loudspeakers can be simplified by using the MA15 installation kit, available from JBL dealers. The kit consists of a self-adhesive sealing gasket, four cast clamps and four machine screws with T-nuts. This permits a greater degree of latitude in the diameter of the baffle cutout and placement of the mounting hardware. The MA15 is particularly helpful when using an existing enclosure in which the cutout has already been made. The clamps and mounting hardware can also be used for JBL 300 mm (12 in) and 450 mm (18 in) speakers, but it will be necessary to make a sealing gasket specifically for such applications. Two MA15 kits should be used to mount the K Series 450 mm (18 in) speaker, due to the weight of this massive unit. The MA15, however, will not fit over the frame of the K145 and cannot be used with this loudspeaker.

If the MA15 kit is not used, the recommended mounting procedure is as follows: place the loudspeaker in position on the uncut baffle board; using the loudspeaker frame as a pattern, insert a drill bit of proper size through each mounting hole that will be used and gently tap the bit two or three times with a small hammer. The resulting indentations on the baffle are where the mounting holes should be drilled.

Remove the loudspeaker and drill through each indentation with the drill size appropriate for the T-nut used. If necessary, use an alignment tool to assure that the drill is perpendicular to the baffle panel. Insert a T-nut into each mounting hole, (from the rear in the case of a front-mounted loudspeaker), tapping it into place so the flange is flush against the panel.

If an error is made in drilling the mounting holes or installing T-nuts, the baffle panel can still be salvaged. Fill in the holes drilled in error with Plastic Wood or a similar filler, again place the loudspeaker in position, rotate it approximately 15° from the original position and repeat the process described above.

Mounting the loudspeaker with wood screws follows the above procedure, except that pilot holes should be drilled only to the depth required by the wood screws.

The seal between the loudspeaker frame and the baffle panel must be airtight. When front mounted, an airtight seal is created by the white tubular vinyl gasket which fits into a groove on the back of the loudspeaker frame. The D208 is provided with a flat fiber gasket which accomplishes the same function. An airtight seal is maintained by the loudspeaker facing gasket when the speaker is mounted from the rear. Note that JBL loudspeakers with square frames are not designed for rear mounting.

When installing the loudspeaker, tighten the mounting screws evenly to avoid the possibility of frame warping; just tight enough to prevent air leaks between the frame and enclosure. Avoid excessive force.

If high frequency compression drivers and horns are used, it is generally most convenient to mount the drivers on the horns before installing the assembled units, following the instructions supplied with the units. The assembled driver/horn combinations should be mounted to the baffle boards before installing the low frequency speakers, so that the low frequency mounting holes can be used for access to the interior of the enclosure.

Although JBL loudspeakers are extremely rugged, the cone and other moving parts are subject to accidental damage. Exercise extreme caution when using a screwdriver or other tools in their immediate vicinity. Whenever a compression driver does not have its horn mounted on it, the mouth of the driver should be covered with plastic tape. An intense magnetic field exists in the mouth of the driver, and it is extremely important that foreign objects such as iron chips, other metallic contaminants, mounting hardware or tools be kept from the area.

Enclosure Finishing

Preparation

The potential for self-expression in finishing an enclosure is limitless. Generally speaking, however, the finish is predicated on the intended use of the system.

The musician's enclosure will probably be moved and handled often. Thus, its finish should be scuff resistant and durable, as well as attractive. Since the home listener's enclosure rarely needs this type of finish, a much broader selection is practical for residences.

Whichever type of enclosure is constructed, remember that it is generally not desirable to finish the enclosure while the components are mounted in it. The enclosure will be easier to handle when it is unloaded and possible component damage can be avoided.

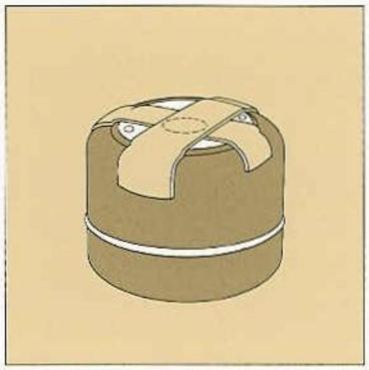
Before beginning the finishing process, flat black paint should be applied to the baffle board so that the mounted components will not show through the grille. Be sure to carefully mask the surfaces that are not to receive the black paint. It may be desirable to mask off the component mounting cutouts to keep paint off of the interior of the enclosure, but a small amount of spray paint on the enclosure padding will not affect its absorptive properties.

Home Enclosure—Oiled Finish

A fine oil finish can be achieved on hardwood veneer surfaces such as walnut by first sanding the surface with 6/0 sandpaper parallel to the grain until it is mirror smooth, using care not to sand through thin veneers. Note that the quality of the final finish depends upon the care with which this initial sanding is done.

Make sure that the surface is completely free of oil, grit and dust. Then apply a liberal coat of finishing oil over the entire surface. Furniture oils designed for this purpose may be purchased at do-it-yourself lumber suppliers or furniture shops, or a finishing oil may be compounded from three parts of boiled linseed oil and one part of pure gum turpentine.

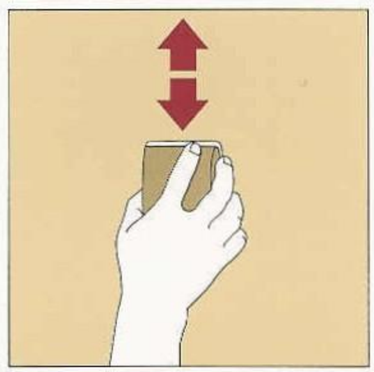
Allow the oil to be absorbed into the wood for about ten to fifteen minutes, and then wipe off the remaining oil with a clean, dry cloth. Allow one-half hour for drying, and then sand the surface lightly with 360 grit wet-or-dry sandpaper. Re-oil the wood and remove the excess after ten to fifteen minutes as above, and allow another half hour for drying. Re-sand the surface lightly with 360 wet-or-dry sandpaper and apply a third coat of oil.



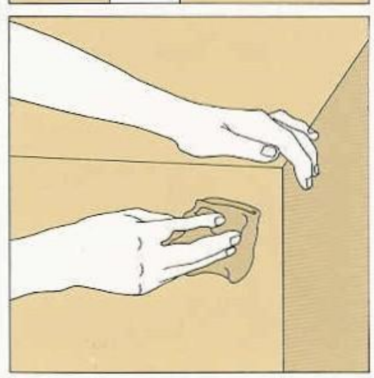
Whenever a compression driver does not have its horn mounted on it, the mouth of the driver should be covered with plastic tape.

Before beginning the finishing process, flat black paint should be applied to the baffle board so that the mounted components will not show through the grille.

A fine oil finish can be achieved on hardwood veneer surfaces such as walnut by first sanding the surface with 6/0 sandpaper parallel to the grain until it is mirror smooth, using care not to sand through thin veneers.

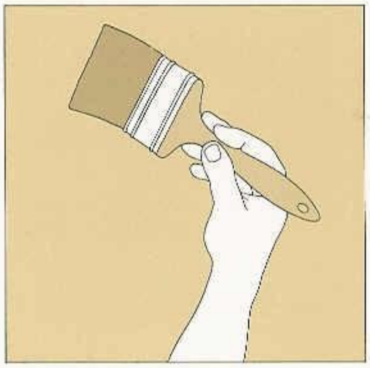


Allow the oil to be absorbed into the wood for about ten to fifteen minutes, and then wipe off the remaining oil with a clean, dry cloth.



Most small scratches which occur can usually be removed by gently rubbing them out with 4/0 steel wool, then re-oiling the surface.

Apply a coat of stain filler, following the instructions furnished with the stain.



After it has dried thoroughly, apply a coat of sealer (thinned lacquer), sanding lightly with 5/0 or 6/0 sandpaper after it has dried.

After this coat has penetrated, the surface should be rubbed down with clean, soft dry rags. The finish is now complete.

It is natural for an oiled finish to appear to dry out after some time, because the oil penetrates more deeply into the wood as time goes on. Consequently, it is necessary to re-oil the enclosure once or twice a year for the first year or two, using the same oil preparation applied during the initial finishing. With each application, the beauty of the finish will increase, and a warm, rich patina will eventually be obtained. Most small scratches which occur can usually be removed by gently rubbing them out with 4/0 steel wool, then re-oiling the surface.

Home Enclosure—Satin Finish

Before beginning this type of finish, note the limitations on ambient temperature during the application of lacquers which are given on the lacquer packaging. If the air temperature is too low, the lacquer will not apply properly.

Sand all surfaces of the enclosure parallel to the grain with 6/0 sandpaper until they are absolutely smooth and level, and remove all oil, grit and dust. Apply a coat of stain filler, following the instructions furnished with the stain. After it has dried thoroughly, apply a coat of sealer (thinned lacquer), sanding lightly with 5/0 or 6/0 sandpaper after it has dried.

Next, apply one coat of clear lacquer, and allow it to dry overnight. Level the surface with 600 wet-or-dry sandpaper. Apply a second coat of clear lacquer and allow at least 24 hours for drying, making sure that the surface is hard. Once again, level the surface as above Wet 4/0 steel wool with water and apply pumice stone to the steel wool to form a paste. Then lightly rub the surface with the steel wool and paste, using long, even strokes with the grain across the entire surface until a satin finish is achieved. Wipe the surface dry with clean, smooth cloths. The finish is now complete. If desired, an occasional coating of any good furniture polish or wax can be applied.

Small surface scratches can usually be removed by gently rubbing them out with 4/0 steel wool and pumice, as above. However, lacquer finishes are extremely difficult to work with, and only small scratches should be repaired in this manner. The home builder should not attempt to remove any scratches that go through the lacquer finish, since these can only be repaired by skilled craftsmen.

Home Enclosure—Custom Finish

Ebony, antique white and other special finishes can be accomplished using wood finishing kits which can be purchased from most lumber dealers, paint stores and other such suppliers. These kits generally include full instructions.

Musical Instrument Enclosure Finishing

The easiest durable finish to apply is to paint the surface of the enclosure with one of the new fiberglass or epoxy resin finishes, following the directions supplied with those products. If this type of finish is not well executed, however, the surface can crack under a very hard blow.

A preferred method of finishing this type of enclosure is to apply Naugahyde or another similar resilient plastic material, available from builders' supply or similar sources. Sufficient material should be purchased so that the top, bottom and both sides can be covered with one continuous sheet, and the back can be covered with another continuous piece. Allow enough excess to overlap and cover the edges of the cabinet.

Start with the section which is long enough to wrap all the way around the enclosure. The seam should be on the bottom panel. Apply glue to both the material and the cabinet, carefully following the directions on the glue package. Note that some glues may not adhere properly to these materials, and others which do may require that the glue be semi-dry before adhesion will occur.

Once the glue is ready for adhesion, begin to apply the pre-glued material to the bottom panel at a point about 25 mm (1 in) beyond the midpoint of that panel. Press the material down evenly, taking extreme care to avoid ripples, bubbles and creases.

Turn the enclosure and continue in the same fashion, covering the side, top, the remaining side and finally back to the bottom again. Overlap the material by about 50 mm (2 in).

Before the glue dries, place a metal straightedge across the overlap at the midpoint of the bottom panel and cut through botn layers of the material with a sharp knife. Remove both pieces of trimmed material. Note that the material will have to be peeled back slightly in order to remove the excess underneath, and should be carefully replaced. The result should be a perfect seam.

Wrap the remaining excess material around the front and rear edges, neatly trimming material which is not covering any surface. 45° miter cuts are not necessary if metal corners are to be installed, as suggested below. Apply a piece of material to the rear of the enclosure if the back panel is not removable, using the techniques detailed above. Make provisions for mounting the connector plate discussed earlier.

Finally, affix metal corners and handles to the cabinet. These may be purchased from most hardware stores. If desired, heavy-duty casters may be mounted on the cabinet bottom. The enclosure finish is now complete.

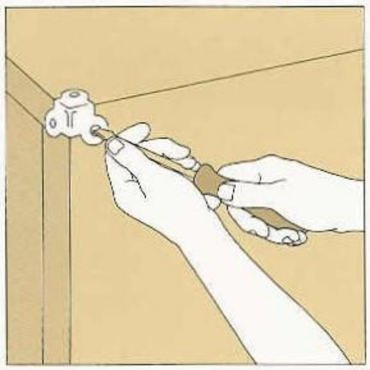
Grilles

Both home and musical instrument loudspeaker enclosures should be covered with grilles to protect the system components from accidental damage. Any sturdy, loose weave fabric can be used. Lightweight polyester stretch fabric has proven to be very good; it has exceptional high frequency transmission characteristics and is quite attractive when stretched over a grille frame. Generally speaking, if the cloth is held up to a light source and can be readily seen through, it will be acoustically transparent. Avoid thick cloth having fuzzy fibers, since these materials will absorb significant amounts of high frequency energy. Sturdy nylon grille cloth may be preferable for musical instrument enclosures, since the material is quite rugged and will not soil easily.

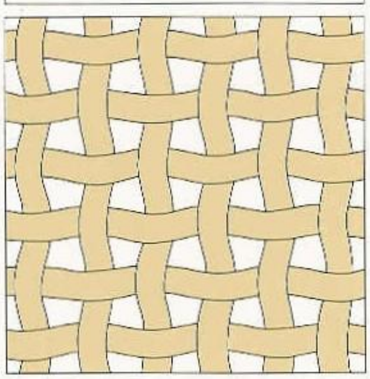
It is generally preferable to mount the grille cloth on a

Before the glue dries, place a metal straightedge across the overlap at the midpoint of the bottom panel and cut through both layers of the material with a sharp knife.

Remove both pieces of trimmed material.

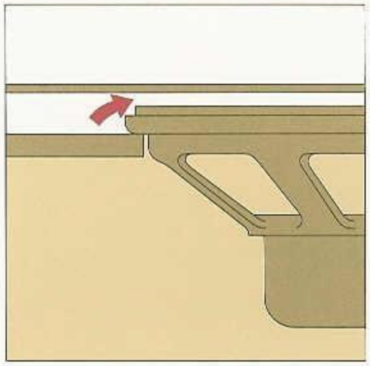


Affix metal corners and handles to the cabinet. These may be purchased from most hardware stores. If desired, heavy-duty casters may be mounted on the cabinet bottom.



Generally speaking, if the cloth is held up to a light source and can be readily seen through, it will be acoustically transparent.

It is generally preferable to mount the grille cloth on a separate thin frame positioned at least 1/4-inch (6 mm) away from the front surfaces of the loudspeakers or the baffle board.



separate thin frame positioned at least 6 mm (¼ in) away from the front surfaces of the loudspeakers or the baffle board. This, coupled with painting the baffle and frame surfaces flat black, will keep the components from showing through the cloth. Hook-and-pile mounting tape, magnetic catches or friction clips can be used to make the frame easily removable. Oval-head screws and cup washers can be used to mount the grille assembly directly to a utility enclosure.

JBL Logos

JBL nameplates are included in this package, and may be affixed to the completed enclosures in several fashions. Since they are self-adhesive, they may be applied to any relatively smooth surface of the enclosure, such as the baffle, sides or back. Direct attachment to the grille is not recommended unless the nameplate is first mounted to a matching piece of metal or thin wood as the nameplate will not permanently adhere to fabric. The mounted nameplate may be affixed to the grille with fasteners from the rear.

Appendix

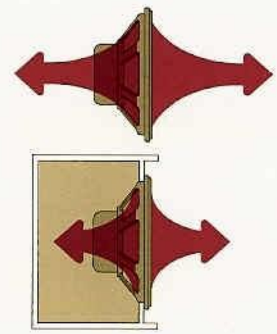
Tuning Procedures For Speakers Other Than JBL

The porting charts in this package give porting recommendations for JBL loudspeakers when mounted in cabinets of specific internal volumes. If loudspeakers from other manufacturers are used, however, these recommendations will probably not be valid.

If the manufacturer of the particular speaker being used gives porting recommendations, those should be followed. If specific porting recommendations are not available but a recommended system tuning frequency can be obtained, the methods below may be used to tune the system to its proper point. If no recommendations are available, proper tuning will have to be determined experimentally.

Several formulas have been published, each claiming to predict exact tuning of an enclosure without actually constructing the system. Unfortunately, these formulas are generally so simplified that they apply only to theoretical loudspeakers; or, alternatively, are extremely complex, requiring sophisticated mathematical analysis of data not available to the purchaser. The methods described here will allow tuning of an enclosure empirically, i.e., by trial and error based on a known goal—the recommended tuning frequency.

It should be noted that there is no specific reason why a ported enclosure should be tuned only to the free air resonance of the loudspeaker, which is the frequency at which the cone vibrates most easily when the speaker is suspended in free air. With modern loudspeaker construction, there are several valid methods for tuning the system. When a loudspeaker is mounted in an enclosure, it interacts with the air in the cabinet and the resultant resonant frequency of the system will no longer be the same as the free air resonance of the speaker.



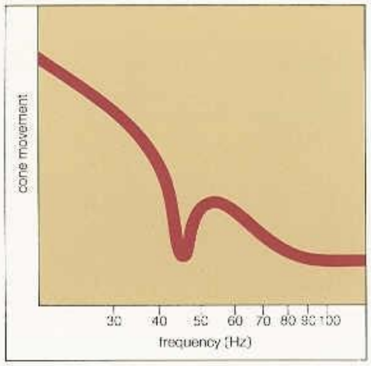
When a loudspeaker is mounted in an enclosure, it interacts with the air in the cabinet and the resultant resonant frequency of the system will no longer be the same as the free air resonance of the speaker.

Equipment

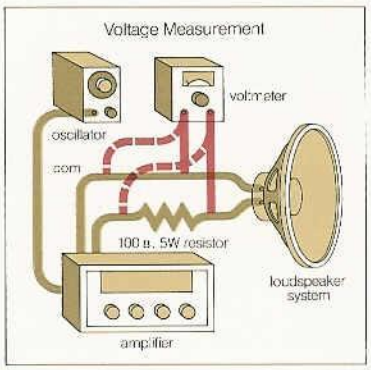
Two methods are described below for determining the tuning of an enclosure; both require an oscillator having continuous sweep capability to 20-25 Hz. Relatively low cost oscillators can be purchased from hobby shops and mail order suppliers. Kits are available and are excellent values. Oscillators may be rented from outlets that specialize in audio and electronic test equipment rental. Many JBL dealers can provide service on their premises and may be prepared to assist the builder in these facilities.

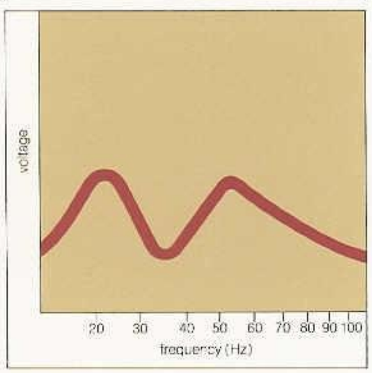
If the system tuning is determined by the second method given (measuring voltage at the loudspeaker terminals), an inexpensive AC voltmeter and a 100-ohm, 5-watt resistor will also be required. Even the most inexpensive meter will be adequate for the voltages and frequencies that will be encountered.

In both methods, the output of the oscillator should be connected to an auxiliary or tape input of a hi-fi amplifier or an instrument input of a musical instrument amplifier. Tone controls, filters and other signal modifying devices should be set for flat response or switched out of the circuit if possible.



The amount of cone movement observed in a reflex system tuned to 45 Hz will vary as shown when an oscillator is swept through these frequencies.





The voltage appearing at the loudspeaker terminals of a reflex system tuned to 35 Hz will vary as shown when an oscillator is swept through these frequencies.

Method No. 1—Cone Observation

This method requires a minimum of equipment or preparation. Sweep the oscillator downward from about 100 Hz and note the frequency at which minimum cone movement occurs. This will be the frequency to which the system is tuned. The graph shows an example of cone movement to be expected from a system tuned to 45 Hz.

If the cone movement is difficult to see, try using a high intensity lamp directed across the cone surface while subduing other room lighting. Movement may be more obvious at the juncture of the center dome and cone or at the cone's outer edge. Placing a fingernail lightly against the cone may also prove helpful.

Method No. 2—Voltage Measurement

This method is more precise than visual observation of cone movement and is basically the method used at JBL.

Connect the equipment as shown in the diagram, with the voltmeter attached to the amplifier output terminals (shown by the dotted lines). Turn on the oscillator and set the frequency to 200 Hz. Turn on the amplifier at minimum volume, and then adjust the amplifier volume control to obtain a meter reading of 10 volts.

Once amplifier level has been set, reconnect the voltmeter across the loudspeaker system (shown by the solid lines). Connecting the meter to the loudspeaker system terminals is often convenient.

With the meter connected as shown by the solid lines in the diagram, the voltages measured as the oscillator is swept downward will look something like those shown in the graph. The frequency to which the system is tuned corresponds to the minimum voltage point between the two peaks. This graph is drawn for a sample system tuned to 35 Hz. The height of the two peaks will vary for each loudspeaker model and cabinet volume, and the two peaks may not be the same height at optimum tuning.

If the upper peak frequency is much less than 50 Hz, it might not be possible to plot the lower curve peak since it could be below the range of an inexpensive oscillator. Incidentally, this curve is often referred to as an impedance curve, although it is referred to here as a voltage curve. Graphs for plotting these voltage curves are provided in this package.

Caution: *Test tones are a much more rigorous load on the loudspeaker than is program material, and can cause permanent damage if the loudspeaker is required to reproduce them at loud levels or for extended time periods. Only moderate volume levels will be required for tuning an enclosure. A good practical guideline is to keep volume low enough so that maximum cone movement is no more than 6 mm (¼ in) peak-to-peak, or 3 mm (⅛ in) from the "at rest" position. Keeping the test tone frequency below 500 Hz will avoid overheating midrange or high frequency transducers.*

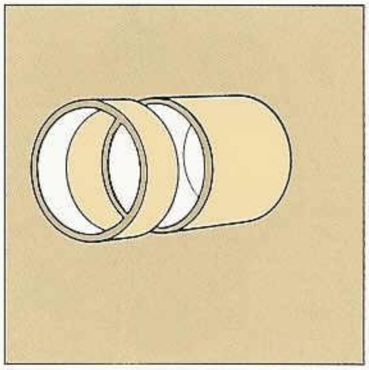
Tuning The Enclosure

If system tuning, as determined by observing cone movement or measuring voltage at the loudspeaker system, is higher than recommended, cover a portion of the port or lengthen the duct if one is used. Conversely, if system tuning is lower than recommended, make the port larger or shorten the duct. Initial changes in port area or duct length should be on the order of 20-25%. As the proper tuning frequency is approached, finer adjustments will be appropriate. However, if the enclosure tuning is within 10% of the recommendation, adjusting the tuning to the precise recommended frequency may result in little or no audible improvement.

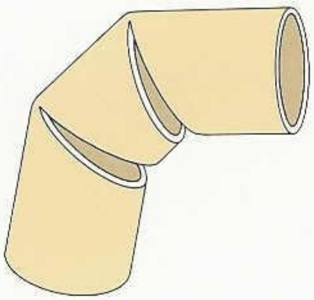
There are several methods which can be used to facilitate making these adjustments. If a ducted port is used, the duct may be temporarily installed from the outside of the baffle board, since it will behave exactly as if it were in its final position on the inside. Further, if suitable concentric telescoping ducting tubes are available, the duct length may be continuously adjusted, and when the final length is determined, a single duct of the proper length may be permanently affixed inside the enclosure.

A straight duct that would come too close (within two or three inches) of the enclosure back panel should be bent 90° for best results. Two "stovepipe" bends can be made in a cardboard mailing tube as shown in the illustration, or a PVC elbow can be used if plastic pipe is used for the ducting. The length of the duct is measured through the center and not at either side. Bending the duct tends to reduce internal port turbulence, resulting in less air noise at the port frequency.

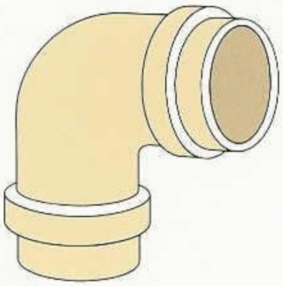
A port without a duct may also be adjusted relatively simply. Make the port oversize and fill it in with small wood blocks until the proper tuning is achieved, gluing the blocks or a board of equivalent area in place once the proper size has been determined. Alternatively, a removable sub-panel with a port may be installed in the baffle board, and the porting on this sub-panel may be varied by partially covering the port with either glue blocks or a board as described above. Then a new sub-panel can be cut with the proper port opening and permanently installed and sealed into the baffle board.



If system tuning is lower than recommended, make the port larger or shorten the duct.



A straight duct that would come too close (within two or three inches) of the enclosure's back panel should be bent 90° for best results. Two "stovepipe" bends can be made in a cardboard mailing tube as shown in the illustration.



A PVC elbow can be used if plastic pipe is used for the ducting.

James B. Lansing Sound, Inc., 8500 Balboa Boulevard, Northridge, California 91329.

Printed in U.S.A. EIM/1-79