Alternatively, using the following box sizes as a guide, go straight to the porting chart for a chosen volume.

	MINIMUM VOLUME		MAXIMUM VOLUME	
	LITRES	CUBIC INCHES	LITRES	CUBIC INCHES
1 x 10	60	3500	90	5500
2 x 10	75	4500	105	6500
4 x 10	90	5500	120	7000
1 x 12	80	5000	110	6700
2 x 12	90	5500	130	8000
4 x 12	100	6000	150	9000
1 x 15	120	7000	200	12000
2 x 15	175		250	15000
1 x 18	100	6000	200	12000
2 x 18	200	12000	300	18000

Then tune the cabinet for the same frequency as the loudspeaker resonant frequency. This will tune the cabinet accurately but will not always provide the optimum result.

Selection of Port or Vent

The porting or venting of an enclosure can take several formats. The simplest being a hole or holes in the baffle. This is not always possible, so an extension 'tube' into the enclosure may be required. These ports or ducts can take any shape, ie. they can be square, oblong or triangular, providing the surface area is correct to the round port area quoted in the chart. Therefore all further references are made to round parts.

$$\text{Port area} = \Pi \times \frac{D}{2} \times \frac{D}{2}$$

where $\Pi = \frac{22}{7}$ D = diameter port for chart

Divide port area by 2 or 4 if this number of ports is required, use result to calculate single port diameter or shape. For circles :

$$\text{Diameter} = 2 \times \sqrt{\frac{A}{\Pi}}$$

where $\Pi = \frac{22}{7}$ A = area of Port

Minimum Vent Diameters

For a single vent in an enclosure there is a minimum port diameter requirement, as ports that are too small can be noisy. For common pipe diameters use the following as a guide.

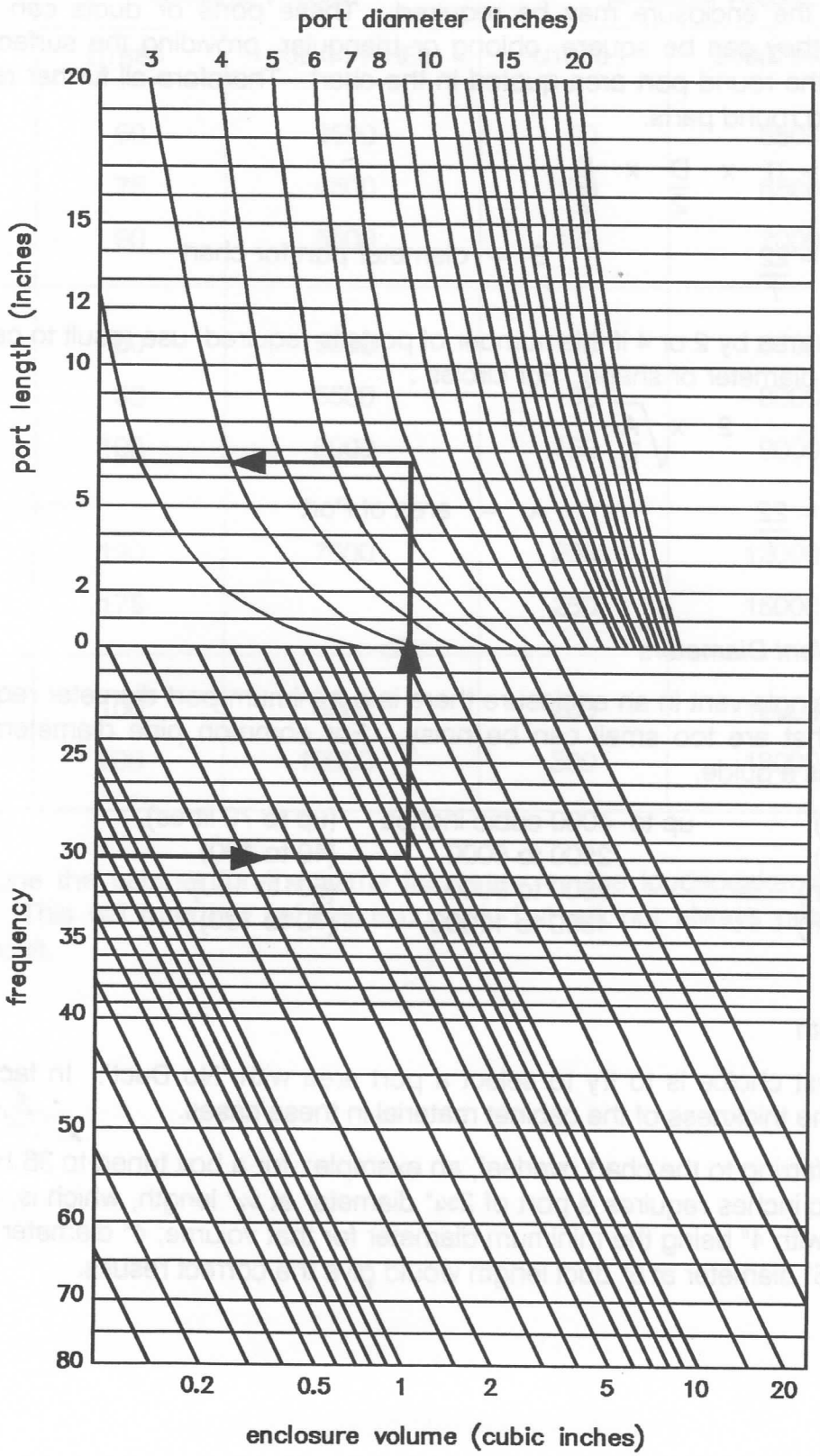
2" (50mm)	-	up to 4000 cubic inches	(up to 70 litres)
3" (75mm)	-	2500 to 6000	(40 to 100)
4" (100mm)	-	2800 to 9000	(50 to 150)
5" (125mm)	-	4300 to 11000	(70 to 180)

Duct Length

The first choice is to try to select a port area with 'No Duct'. In fact the duct length is the thickness of the cabinet material in these cases.

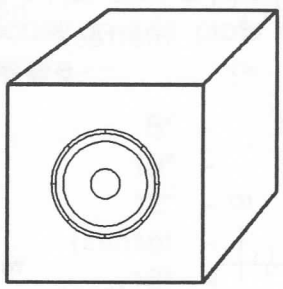
So, referring to the chart overleaf, an example: for a box tuned to 38 Hz, volume 8600 cubic inches requires a port of 2¾" diameter at ¾" length, which is, of course, too small with 4" being the minimum diameter for that volume; 4" diameter at 3" duct length or 5" diameter at 6" duct length would give the correct results.

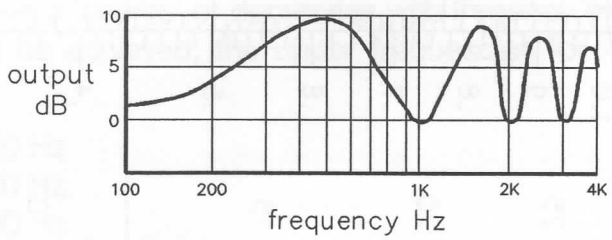
PORT OR DUCT SELECTION CHART



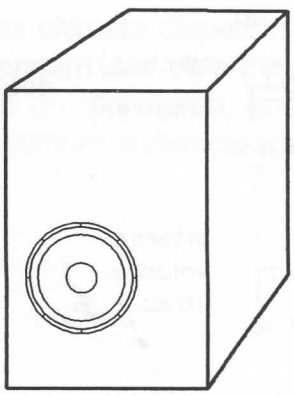
1.4.3 Ideal Enclosure Dimensions

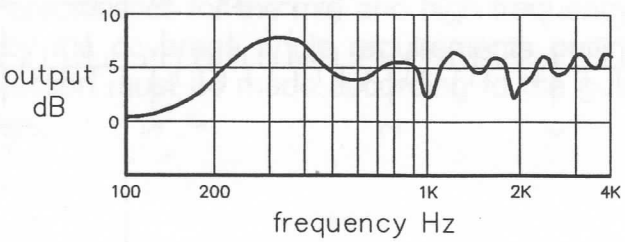
In order to avoid internal standing waves within the enclosure, and to minimise panel resonance and refractions caused by parallel sides, the internal dimensions of an enclosure should not be common multiples of one another. The accepted ratio of height/width/depth is 2.3/1.6/1.0. The illustrated nomogram can be utilised to quickly determine the ideal internal dimensions for a selected volume, or the volume to available dimensions. Note that the effective internal volume of an enclosure is the net volume of the main working chamber minus any intrusions. In addition it should be recorded that in order to minimise the defraction effects in the frequency response caused by external enclosure corners, the loudspeakers should not be placed dead centre in the baffle. The defraction occurs over the entire frequency range, therefore the asymmetric placement of all loudspeakers is beneficial. In a multi-way enclosure, the units should be arranged so that they have unequal direct path lengths to the baffle corners. See illustrated examples.





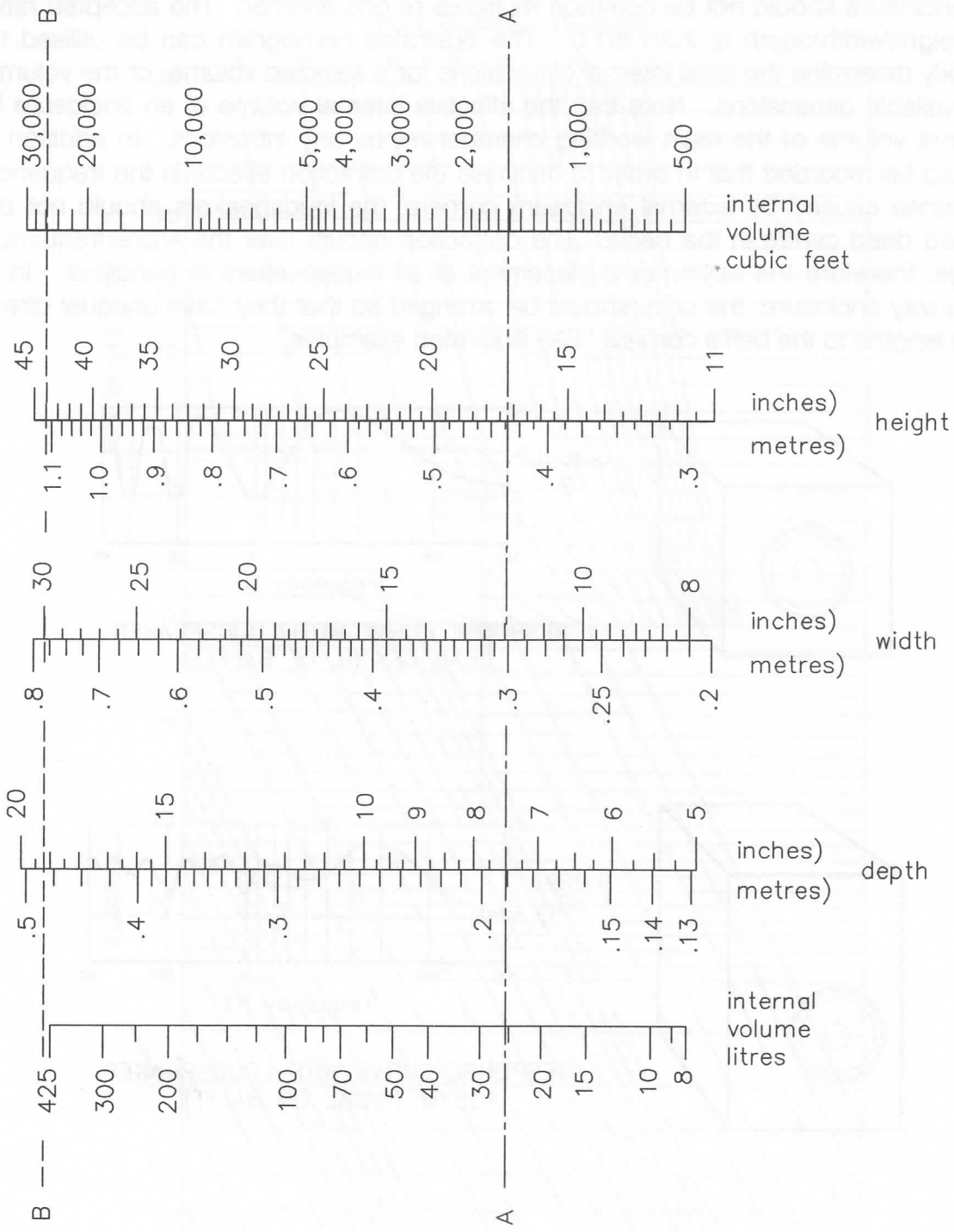
RESPONSE CURVE WITH LOUDSPEAKER
DEAD CENTRE OF BAFFLE





RESPONSE CURVE WITH LOUDSPEAKER
ASSYMETRICAL ON BAFFLE

NOMOGRAM TO DETERMINE IDEAL ENCLOSURE DIMENSIONS AND PROPORTIONS



Example A:
1,500 cubic feet = 17" high x 12" wide x 7.49" deep

Example B:
26,000 cubic feet = 44" high x 31" wide x 19.25" deep

1.4.4 Mid-range And High Frequency Systems

The introduction of a mid-range loudspeaker or enclosure into a system has many benefits:

- Improvement in power handling
- Increase in output efficiency
- Better dispersion
- Improved sound quality

The improvement in power handling is related to the crossover frequency and can be optimised for maximum performance and efficiency as the displacement excursion is small over the restricted bandwidth.

The main improvement in sound quality is due to using specifically designed drivers for each band and the subsequent reduction of modulation distortion at high output levels.

The dispersion of cone drivers 'beams' or decreases with freqency even though exceptional on-axis plots can be achieved; the upper frequencies for -6dB at 90 degrees are -

8"	-	2100 Hz
10"	-	1700 Hz
12"	-	1500 Hz
15"	-	1100 Hz
18"	-	1000 Hz

Mid-range enclosures are normally sealed, the volume being for the ideal Q of 0.707. The mid-range driver should never be in the same compartment as the bass driver as it will be modulated by the low frequency resulting in poor performance.

The ultimate dispersion characteristics for the mid and high frequency sections of a system are determined by the coverage angle requirements outlined in the section on dispersion, and selection must be made according to the guidelines to give optimum audience coverage.

1.5.1 Construction

Fittings and Finish

When you have selected the enclosure designs that you wish to construct there are a number of other decisions that have to be made at this stage before work commences. These are the type of finish to the woodwork, the method of protecting exposed loudspeaker cones, and any other ancillary fittings required for a cosmetic finish or to assist in use. All of these have an influence on the next stage of construction.

The surface finish to the enclosures woodwork is generally a matter of personal taste, some common, easy to apply examples being as follows:

Staining or Painting

Black oak or similar stain is ideal for enclosures that are used extensively in touring and mobile applications as dents and scratches can be easily retouched. It is really only suitable for good grades of plywood. Paint finishes offer similar attributes to the above, however they do give greater flexibility if the colours required are to match the decorations in the fixed installations. Enclosures can be camouflaged for an integrated look, or made into a feature by highlighting in contrasting colours. For a truly professional appearance, time and care is required in preparation and good quality sealers and primers used.

Pre-Finished Boards

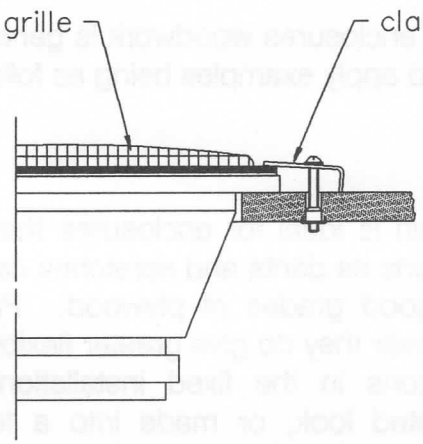
This material is available in standard sized sheet form and usually has one or both surfaces finished or even laminated with a tough, hard wearing plastic. It is very popular on musical instrument backline enclosures that are 'Flight Cased'.

Soft Surfaces Finishes

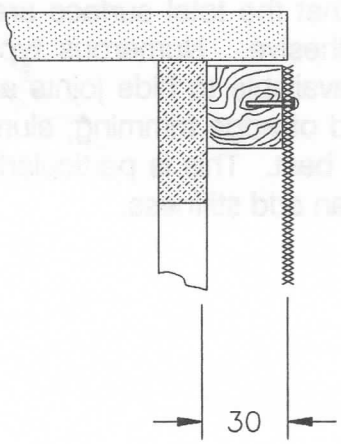
Textured vinyl, felt carpet, or similar soft coverings provide pleasing cosmetic appearances and if handled carefully are reasonably durable. When applying these materials to the woodwork it is important to that the total surface area is bonded preferably with a PVA type woodworking adhesive. Numerous types of plastic corner protectors and extruded edgings are available to hide joints and provide a professional finish. For a really robust method of edge trimming, aluminium 'Flight Case' strips and plated metal corners are the best. This is particularly suitable for chipboard enclosures where the metal frame can add stiffness.

If the design you require has exposed loudspeaker cones, consideration to the method of their protection needs to be included into the construction.

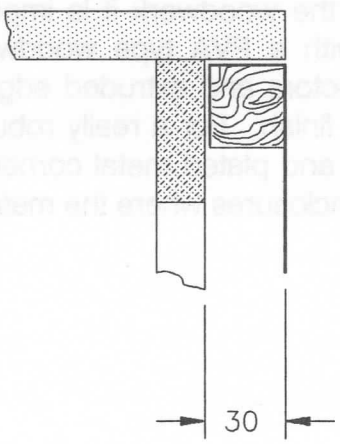
A convenient solution is the use of metal individual loudspeaker grilles. These are readily available in all the standard loudspeaker sizes and are usually supplied with a neat finishing trim. The grille can be fixed by either clamping with conventional speaker clamps, or securely bonded onto the loudspeaker front.



An alternative method to individual metal grilles is the full frontal cabinet grille. These are usually made from perforated metal (minimum 50% open area), open-cell foam or a special loudspeaker grille cloth that is acoustically transparent. All these types of grille usually require a wooden supporting frame. It is important that this frame does not cover any ports and the inside face of the grille is clear of the maximum forward movement of the loudspeaker cones. The best way to secure metal grilles is with screws and cloth can be glued or stapled. There are numerous types of snap fit or velcro fasteners available to secure the wooden frame.

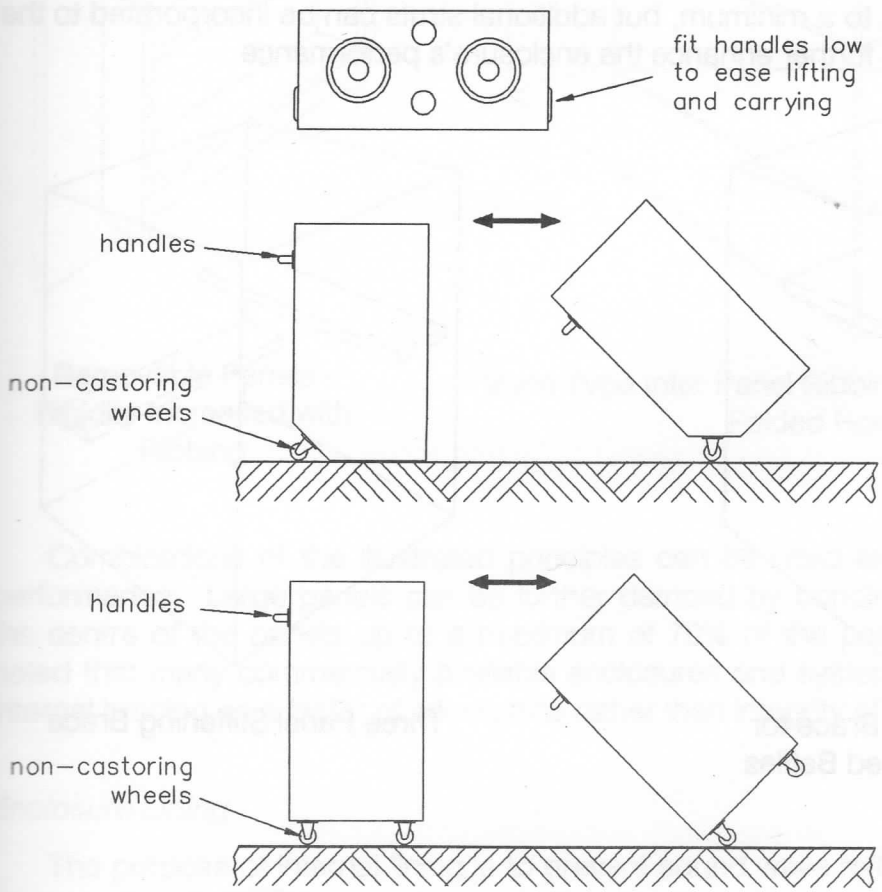


metal cabinet grille



cloth cabinet grille

For final finishing details to your enclosure, there is a wide range of carrying handles, castors, feet, and other optional fitments available from specialist suppliers. Rubber feet must always be used between stacking cabinets. Handles and wheels should be carefully positioned to allow ease of transportation without risk of personal injury. All of the designs contained within this handbook will pass through a standard 30" (760mm) doorway on the least one axis.



Position Handles and Wheels to give greatest Ease of Movement

Enclosure Panel Material

The selection of material for the construction of the main outer panels of enclosure is dependent on its intended use and also the available budget. For large P.A. touring cabinets Marine Birch plywood is the most durable material available. Indeed many hire companies use only this material in a painted finish, and continuously repaint for each tour.

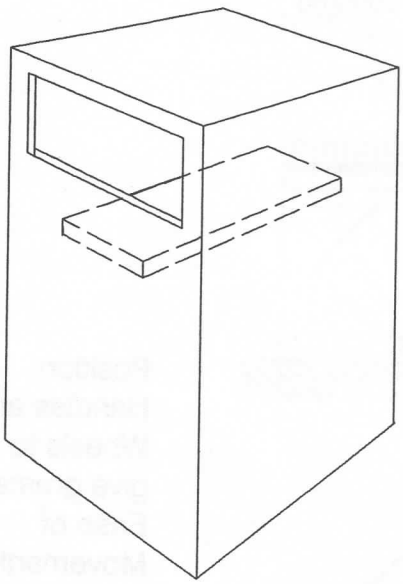
Chip or particle board is the most cost effective and widely used material. It does require surface coverings, edge and corner protection for mobile use, and is in fact denser than birch plywood. The method of manufacture produces an apparently hard surface but this is not to be considered as durable.

Medium Density Fibre Board (MDF) is even denser than chipboard, it has a higher internal strength and is far harder. It is extensively used for domestic Hi-Fi enclosures because of its superior 'sonic' properties. It is, however, a difficult material for the amateur to use without the appropriate woodworking machinery.

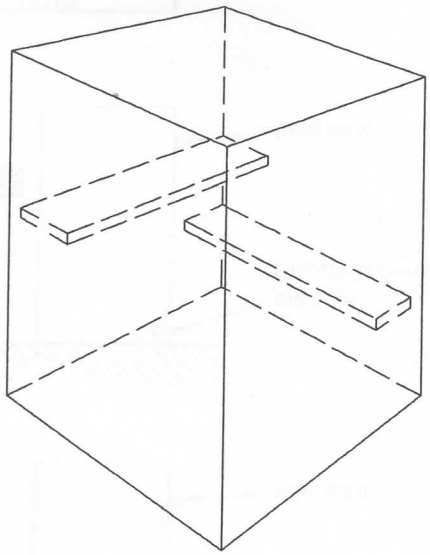
Combinations of the various materials discussed above may be used to achieve all the desired parameters of durability, cost, and workability, ie. plywood outer panels, chipboard inner panels and braces.

Internal Bracing and Box Damping

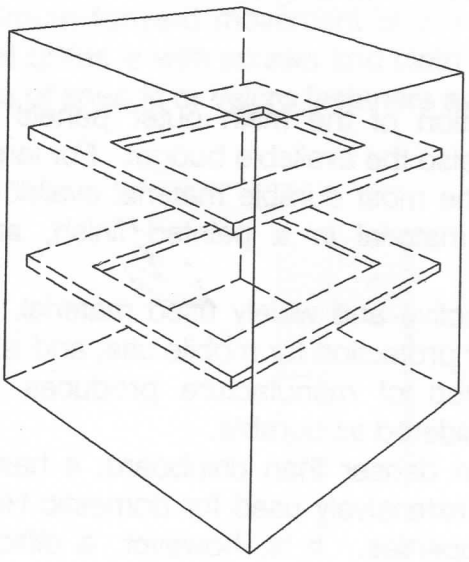
The energy produced by high power bass drivers in any enclosure causes the panels to resonate. The high internal forces generated can cause panels to radiate as much power as the loudspeaker itself if it is not properly dealt with. All designs within this handbook have avoided large unbraced panel areas throughout, by use of bracing struts. However, in order to keep the drawings as simple as possible, these have been kept to a minimum, but additional struts can be incorporated to the following principles to further enhance the enclosure's performance



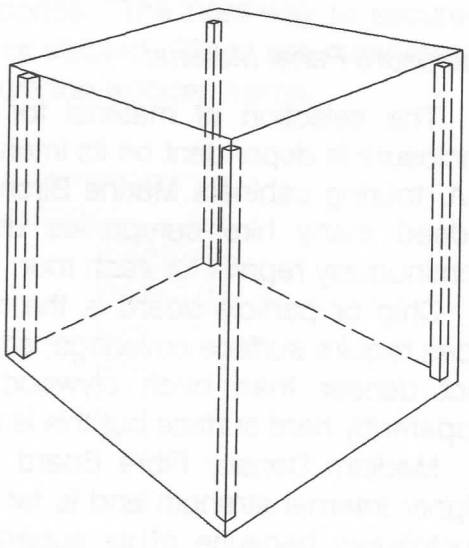
Front to Back Brace for Large Weakened Baffles



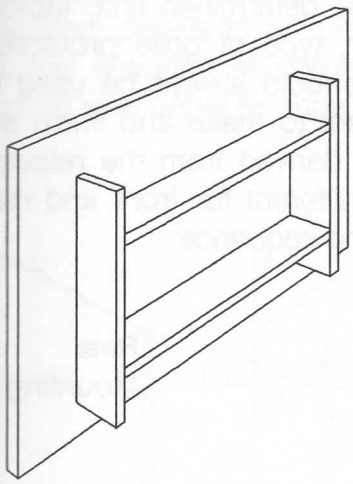
Three Panel Stiffening Brace



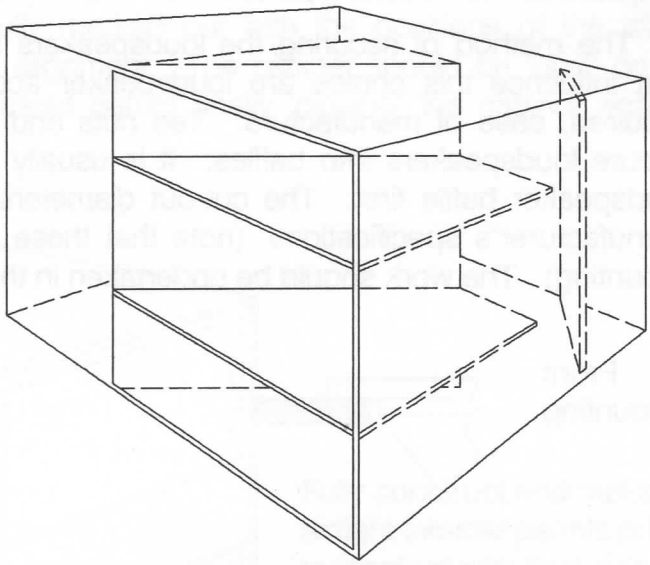
Bulkhead Type Ribbing - Ideal for Large Plain Enclosures



Corner Joint Battens, Screwed and Glued add considerable strength and stiffness



Removable Panels - Rigidity Increased with Ribbing



Vane Type Inter Panel Ribbing - Ideal for bracing Folded Horns

Combinations of the illustrated principles can be used extensively to improve performance. Large panels can be further damped by bonding bitumen pieces to the centre of the panels up to a maximum of 70% of the panel area. It must be noted that many commercially available enclosures and systems avoid any form of internal bracing as a factor of economics rather than integrity of design.

Enclosure Lining

The purpose of internal lining is to prevent sound wave reflections and standing waves. Box linings do not decrease the effective volume of the enclosure. The lining material should be loosely packed on all surfaces; the art of compressed boxed stiffening ought to be avoided as it requires scientific assessment and testing. All sealed and reflex designs are most effectively lined with 2" (50mm) thick glass fibre insulation wadding as used in the home. Light density B.A.F. type waddings as used in Hi-Fi enclosures are not effective enough for high power use. Note that any design incorporating a folded horn should not be lined at all in the flare paths, the loudspeaker chamber however should be adequately lined. In bass reflex designs care should be taken to ensure that lining material does not obstruct ports and ducts, and cannot be dislodged thus forming an obstruction. Sealed mid-range chambers should be adequately lined on all surfaces. Horn and tweeter enclosures do not require any form of lining.