Russ Andrews®
Solutions for better music & movies

Loudspeaker Upgrade Handbook

Contents

The Russ Andrews Solution

A large number of Hi-Fi enthusiasts own systems which they have built up over many years; a personal selection of equipment providing a well loved sound. The urge to improve is, however, inevitable especially when we are constantly being told by the Hi-Fi press of the desirable improvements offered by new technology. The traditional approach to improving a system is to buy ever more expensive bits of hardware, but is this really the best solution?

At Russ Andrews we believe that this approach is misguided. New models do not necessarily perform better, are frequently more expensive and rather than solving problems often just lead to different ones. We believe that (with very few exceptions) the most cost effective and satisfying way to improve the sound of your system is to upgrade the equipment by using better quality internal components: resistor, capacitor, wire etc. That way you get to keep the well-loved sound of your system whilst improving the quality of it – and save yourself disappointment, frustration and money!

If you have some electronic know-how, upgrading your own system is an enormously rewarding and enjoyable project. Many of the improvements described here require only patience – which you provide free! – but the results can be quite stunning.

If you do get stuck whilst carrying out the upgrade, we are happy to help you out if you run into difficulties. We have the facilities to repair almost all equipment if you get *really* stuck!

How to get the best out of your loudspeakers

The loudspeaker is a good place to begin the process of upgrading, both because it generally has the greatest potential for improvement, and because the components are large and easy to handle so making it the easiest unit for the amateur home upgrader to tackle. Improvements are largely gained by improving the crossover and by improving the quality of wiring. There are other modifications which can be made to cabinets, drivers and damping that improve performance further.

Upgrade Areas in a Loudspeaker

1. Cabinets
2. Internal Damping
3. Drive Units
4. Speaker Terminals
5. Internal Wiring
6. Earthing your speakers
7. Crossover Network
8. Speaker Stands

Burn In Period

After upgrade, your loudspeakers will need at least 300 hours of use (burn-in) before they settle down and give their best. The quickest way to achieve this is to leave them running quietly 24 hours a day for 3 weeks (in between playing them loudly just for the fun of it!)

Tools & Solder

Soldering irons

Two types of soldering iron will be helpful. A 30 watt with a reasonably small tip is perfect for small signal wire and printed circuit board (PCB) work, and a large 40 to 50 watt is ideal for bigger work like cables inside speaker cabinets. Don't be tempted to use or buy one of those pathetic little 15W irons they advise you to use with transistors. They do more harm than good. The secret of good soldering is to use an iron with a high thermal mass so that the tip can maintain its temperature, and a tip of the right size for the job. We use 50 watt irons with 4mm to 6mm tips for large joints and 30 watt irons with needle points to 3mm tips for fine work. It is well worth investing in good tools if you want good results.

Solder

Solder is now an issue with the Restriction of Hazardous Substances Directive and all new equipment must be made with lead-free solder. Repairs, or rework with leaded solder is still permitted for equipment made with leaded solder. It is important not to mix the two because they don't work well together and dry joints (a type of badly soldered joint where the solder fails to wet the metal) are difficult to avoid. We stock both types of Wonder Solder (the best sounding solder we can find). We use it on all our own work: it contains 5% silver and the leaded version only 3% lead.

Other tools

Be prepared to use any of the following tools – I have!

- Hot melt glue gun
- PVA wood glue- for sealing cabinet joints
- Wire cutters
- Wire strippers
- Screwdrivers
- Spanner
- Pliers
- Jigsaw
- Hammer
- Chisel
- Scalpel
- Jemmy (aka. Pry-bar, crow bar)
- Rasp file
- Electric drill
- Wax stick (wood colour)
- Cabinet maker

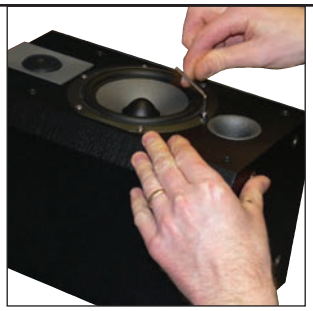
1 Cabinets

The way into loudspeakers is by removing the drive units. There is much you can do to improve the cabinet and reduce resonances.

Run PVA glue along all internal joints to make sure they are air-tight – not dry, rattling, leaky joints. Cabinet manufacturers never put enough glue into joints to ensure a good airtight seal. I've come to the conclusion that they simply hate to have excess glue coming out of the joints.

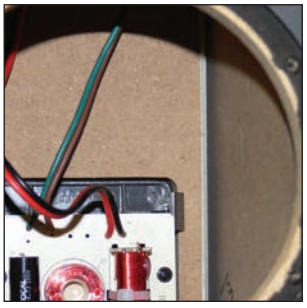
Veneered chipboard or medite MDF cabinets benefit tremendously from being lined with insulation board – a soft, fibrous material that absorbs sound very well. Glue it hard side down on top of any sound deadening pads that may already be glued to the panel. Cover approximately half the panel area, and stick it to the centre of each panel.

Cone Feet. Speakers are best mounted onto stands with Cone Feet. Do not use Blue-Tak as it almost guarantees one-note bass or muddled midrange. The only possible use I can think of for it is that it stops the speakers sliding off the stand! Our Small and Big Cone Feet come with self-tapping screws to allow you to fit them to the wooden cabinets of loudspeakers, or you can glue them if you wish.



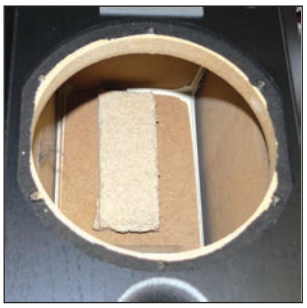
Use a screwdriver or allen key to remove the main drive unit

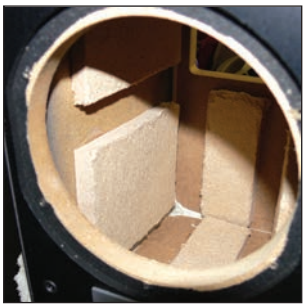
Gently pull it forward to get access to the cabinet



View of the crossover

Apply hot melt glue to the insulation board





And apply it to cover approximately half the panel area

2 Internal damping materials

Commercial loudspeakers use foam, Bonded Acetate Fibre (BAF), glass fibre or, rarely, long-hair wool.

Our Acousti-Wool is undoubtedly the best material to use to absorb cabinet cavity resonances: foam sounds muddy, distorted and confused; BAF sounds like as if it isn't there (ie. doing nothing); and glass fibre wadding sounds plain nasty. Foam covered SD pads are undesirable as are Deflex panels in our opinion.

The exact quantity of Acousti-Wool is important, to avoid over- or under-damping the bass. It is supplied in 'sheets': as a very rough guide, you'll need 1-2 sheets per medium-sized bookshelf speaker and 3-4 sheets per medium-sized floorstanding speaker. If you have used too much or too little, you will have overdamped or underdamped the bass, so remove some wool or add some as necessary. The sheets can be easily cut to size with scissors.

Remove the old internal damping material

3 Drive units

Drive units can often be improved with a little patience and inexpensive materials.

Tweeters

Check tightness of any faceplate fixing screws – they tend to loosen in time and produce odd buzzing noises.

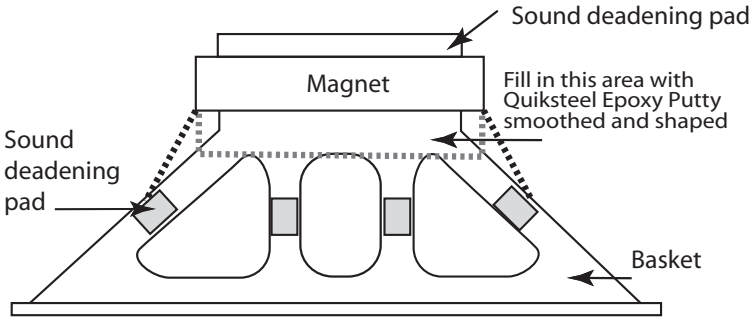
Fit a piece of EAR Isodamp sound deadening pad to the back to damp rear cavity resonances.

Fit a Focus Ring round the face plate or on the baffle to absorb spurious reflections.

Midrange, Mid/Bass & Bass Driver

The best chassis are alloy castings as they are the stiffest and have least ring resonances. Pressed steel chassis can, however, be improved by sticking Bitumastic Sound Deadening pads to the struts and strengthening the joint between the magnet and the basket (see diagram). Use epoxy resin car body filler or Quiksteel Epoxy Putty: it is effective and easy to use. Alternatively, you can use hot melt glue.

Fit a sound-deadening pad to the magnet assembly and to the struts as illustrated below. Use a Bitumastic Sound Deadening pad or foil-backed Sound Deadening pad



The result is a faster, cleaner, less coloured sound with much better bass.

* Earthing terminal - see page 10

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Drive units are usually fitted to rebated cut outs in the front baffle with foam gaskets to give an air-tight seal. An air-tight seal is essential, but a compliant foam gasket is undesirable because it allows slight movement of the driver when it is working. This slight loss of rigidity is small but the effect is large, causing loss of fine detail and softening of attack. Midrange is clearer and bass better defined if the air-tight gasket is made of hard material.

Epoxy resin car-body filler makes an excellent gasket. Mix the filler and spread a thinnish layer in the cut-out where the driver gasket sat. Spread a thin layer of Vaseline on your drive unit over the area covered by the original gasket drive unit flange, where the original gasket sat, so that the epoxy resin doesn't stick to it. While the resin is still soft, fit the drive unit and screw it down. The aim is to fill all the gaps under the driver rim to make it air-tight. Scrape off the excess before it sets hard!

Mark the driver and baffle so that you can refit the driver in the same orientation in the future – it probably won't seal properly any other way round.

Remove the driver and clean off any excess filler and the Vaseline. You should now be left with a perfect fit gasket.

Driver screws

Most screws provided to screw drive units into baffles are cheap, useless self-tappers that mash up the chipboard baffle. We stock double-threaded screws that do a perfect job of fixing the driver securely.

Speakers with medite baffles often use 'T' nuts and bolts. Unfortunately if you overtighten the bolts, the 'T' nut neck stretches and looses tightness. The best remedy is to remove the 'T' nuts, plug the hole with dowel, and then use our special drive unit screws.

4 Speaker terminals

The best-sounding binding posts we have found are WBT's nextgen™ 0710-Cu (gold-plated copper) and 0710-Ag (silver). Our 30A nickel plated binding posts are the next best. Do not waste your money on other gold-plated binding posts, they sound brash, bright and nasty when compared even to our nickel-plated posts. This also applies to banana plugs and phono plugs!

For manufacturers, 4mm banana plugs and binding posts were thought to be outlawed by the EC, because continental mains sockets are two-pin 4mm, and they are afraid that people might plug their speaker leads into the mains! You, as an owner, are not bound by these laws so whatever the manufacturer fits, refit with the best connector! Most manufacturers seem to have gone back to 4mm binding posts… who knows what the law says?

5 Internal wiring

Don't use different types of wire in a loudspeaker. Each type of construction has its own phase characteristics and the differences can sound weird.

If you wish, use thicker cable for the Bass or Bass/Mid driver, but don't use very thin wires for the Treble. You can use Kimber Speaker wires like 4PR, 4VS, 4TC or 8PR, 8VS or 8TC, or the special internal wire like TCX. For example use 8TC for bass and 4TC for Treble, or TCX for all drivers.

When routing the wires keep them away from the drive unit magnets to reduce colouration.

Do not use thin wires – even if they are silver – the result will be thin, hard and disappointing.

6 Earthing your speakers

Some loudspeaker manufacturers - for example, Tannoy and us (in the Russ Andrews Quave LS1 speakers) - helpfully provide an extra binding post that lets you earth the speaker drive units for better sound quality. This is connected internally to the chassis of the drive units, and allows you to connect these sockets with green/yellow earth wire to the earth terminal, such as those fitted to high quality mains extensions, our SuperSockets, or the earth pin in a mains plug, to benefit from improved clarity and enhanced spaciousness.

If you don't have earthed speakers, you can test this upgrade fairly easily for yourself without having to modify the drive unit. When you remove the speaker grille, you will find the tweeter(s) and one or more drive units held in with screws. Tackle only the drivers and tweeters with metal bodies. Drivers and tweeters that have a plastic chassis do not need earthing!

Remove one screw from each driver and clean the metal around the screw hole to remove any paint. Strip the end of a piece of earth wire that is long enough to reach your mains socket (you are going to use its earth), make a small loop in the stripped end and refit the driver screw through it so that it makes a good tight connection with the chassis. If there is more than one driver on each speaker, you can earth link them together or run two lengths of wire.

Take the opportunity to check the tightness of all the driver screws but don't be tempted to over tighten them. Do both speakers and fit 13 amp plugs to the earth wire (using only the big earth pin!) so that you can easily A/B the difference.

If you like what you hear, you can make the connection permanent. Make the connection at the *back* of the driver (inside the cabinet) and run the earth wire to an extra socket on the back plate, next to the usual speaker terminals. If you find the tangle of earth cable unwieldy, a Star Grounding Block is perfect to link all your earth cables together.

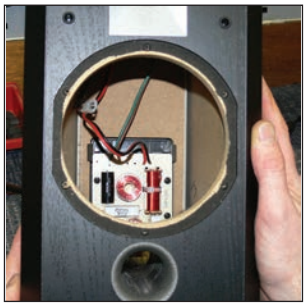
7 Crossover network - Quality first

Most speaker manufacturers dismiss the significance of component quality. It has become increasingly obvious to us, however, that component quality has the single most important influence on sound quality. Over the last 25 years we have been in the forefront of research in this area, selecting the best components the world has to offer, and if the best isn't good enough spending time designing and developing our own audiophile components.

'Better components produce better results!'

Our basis for selection is a combination of both sound quality and reliability. The components are made specifically for high quality audio use using the very best materials and construction techniques available.

If quality is so important you might ask why commercial manufacturers use the cheapest components they can find eg. Bipolar electrolytics, ferrite inductors, wire wound resistors. Competition is largely to blame for this. Manufacturers are compelled to steadily cut the quality of their products in order to sustain prices and profit margins against inflation and competition. Products are made to fit artificially created price-points, so whether £99.95 or £999.95 the same price-led design compromises occur where designers opt for cheaper components and often increasing circuit complexity in an attempt to tame the side-effects of these components. They insist that the resulting losses in efficiency don't matter, that all you need to do is to turn up the volume to compensate. They then design complex, inefficient crossover networks trying to make loudspeakers that have flatter response curves. Most speaker manufacturers seem to believe that the most important aspect of a loudspeaker's performance is a flat frequency response: it looks good on paper but the price you pay is in loss of musicality, dynamics and information. The reality is that complex crossovers generally sound flat, two dimensional and boring.



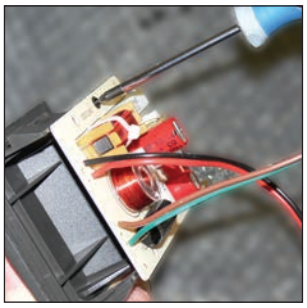
The crossover mounted on the binding post backing plate

In our case the backing plate can be released more easily if you soften the plastic clips attaching it to the casing

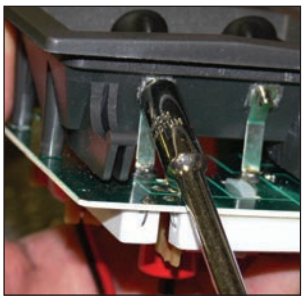
The backing plate will then slip out

The backing plate removed with the crossover mounted onto it

Unfortunately, the complex crossover network poses serious problems for amplifiers, too (see *Input Requirements of High Quality Loudspeaker Systems* by Ilpo Martikainen, Ari Varla & Matti Otala, March 1983. AES 73rd Convention, Eindhoven). The AES paper describes measurements of 3 commercial loudspeakers. They all draw currents larger than expected from that suggested by their nominal impedance. The two-way design in the test measured a staggering 5.3 times the expected current. This required a peak output current of more than 30 amps on normal musical signals! The effect of demanding more current than a normal amplifier (a normal 100W amp could be expected to deliver between five and eight amps) can deliver is a massive increase in distortion when you play the loudspeaker at anything above modest sound levels. The price you pay for inefficiency!



Unscrew the crossover circuit board from the backing plate



Remove the crossover

Not only do good quality components sound audibly better, but an important side effect of this is that they have much lower losses than conventional cheap commercial products which means that when you build a crossover network with them the speaker increases in efficiency: it plays louder, has more retained information, is faster and more dynamic, and has lower distortion. It follows, therefore, that the use of better components offers the prospect of circuit simplification. Circuit simplification is always possible and brings huge benefits in efficiency, clarity and realism.

The solution is remarkably simple, especially in a two-way loudspeaker. Take out the crossover network and replace it with one capacitor! The bass/midrange driver operates full range and the tweeter is rolled on by the capacitor; the improvements in musicality, communicativeness and sensitivity easily outweigh the cost in frequency response flatness terms.

It is so easy and effective that we have created a Loudspeaker Upgrade kit to make the selection of the capacitor value easy to find for the non-technical.

Upgrading a 2-way speaker's crossover with our Capacitor Kit

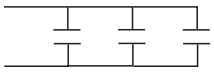
Replacing the crossover with a single 'cap' should be the last stage of the speaker upgrade process. This is because the capacitor sets the final balance between treble and bass. It is easiest done by ear using white noise from a test generator, test LP or test CD. If you have none of these, the inter-station noise on an FM tuner is a good source of 'white' noise. (White noise is a noise source that is wideband but with no tonal content. It should have equal energy at all frequencies.)

If the speaker is properly balanced, the white noise will sound as if it has equal energy at all frequencies. No driver should sound louder than another. If they are correctly phased, the sound should blend together seamlessly. If it is wrong, the drivers will sound quite separate, and not integrating evenly. It is possible that your speakers are not properly balanced or phased in the first place.

From the kit, start with the 2.2µF value connected in a temporary manner to allow easy value changes. If the treble sounds too bright with this value, try the next lower value and so on until a good balance is achieved. If the sound is too dull or 'dim' with 2.2µF try the next higher value until a good balance is achieved.

You can get intermediate, lower or higher values by putting capacitors in parallel or in series. Capacitors in parallel simply add in value;:

1µF + 1µF = 2µF.

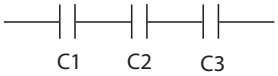


Circuit diagram

However, if you put two identical values in series, the result is half the value of one of them ie.

1µF + 1µF = 0.5µF.

If you use different values, you must do the maths to find the resultant value (or use a capacitor meter!). Capacitors wired in series in the following ratio:



Circuit diagram

Formula:
Capacitors in series:

$$C_{total} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}}$$ etc.

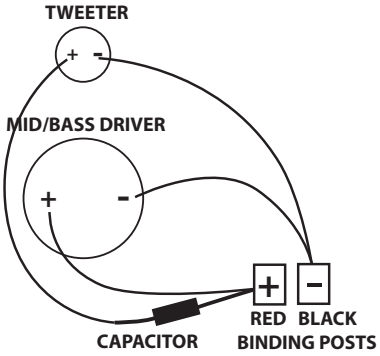
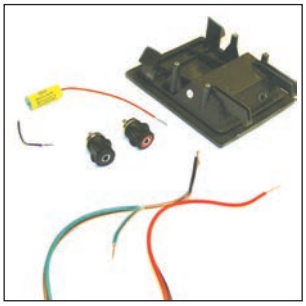
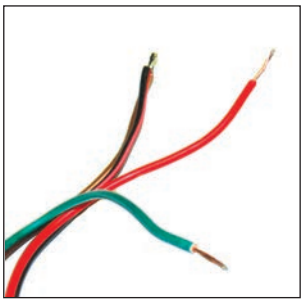


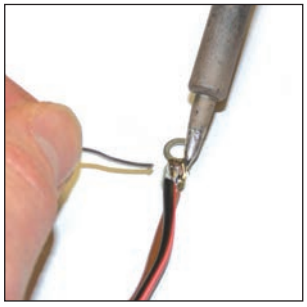
Diagram showing how the tweeter is 'rolled on' with a single capacitor. The mid/bass drivers operates full range



Preparing to fit the capacitor, having removed the crossover

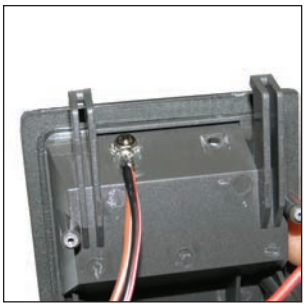


Twist together the two negative wires, leaving both positive wires separate

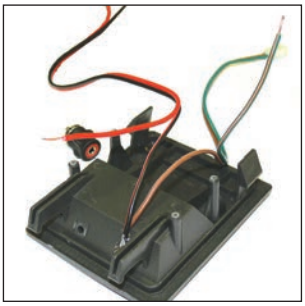


We're soldering an eyelet to the negative wires to attach to the negative (black) binding post

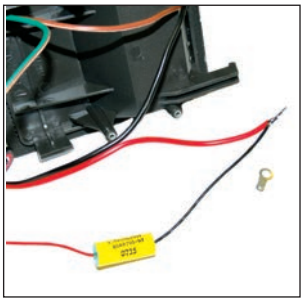
Rewiring the crossover using existing cables



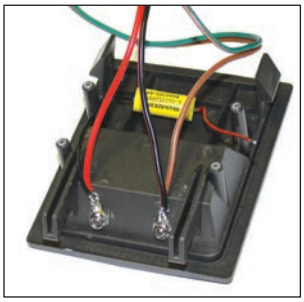
Solder the negative wires to the black binding post



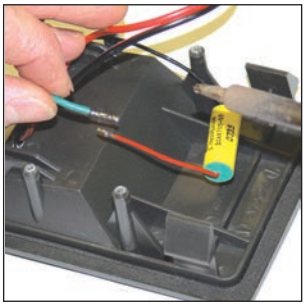
Take the positive wire to the bass/mid drivers



And solder the negative lead-out wire of the capacitor to it ...

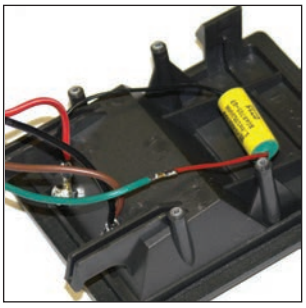


then solder both these cables to the red binding post

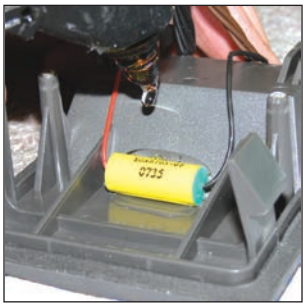


Now, taking the positive lead-out wire of the capacitor...

solder it to the positive wire leading to the tweeter



Once connected, your circuit is complete



When you are happy with the value of capacitor you have used, fix it in position with hot melt glue and reassemble your speakers

When you have selected the capacitor value that gives the best balance on white noise it is worth checking that the phase of the tweeter is correct. If it is not, then you will have found it impossible to get the sound from each driver to blend together properly. Just reverse the connection and listen to the results. If you have a sweep generator and a spectrum analyser you would see that the wrong phasing would produce a response dip at the crossover point compared to a smooth transition with the correct phase. Some tweeters are designed with the phase correction built-in and some are not, so the only sure way is to listen each way and select the correct one.

It is possible that the relative sensitivities of the drive units is so great that the capacitor alone is insufficient to achieve a good balance. In that case a low value 2 or 3 watt resistor will be needed in series with the capacitor. Values from 1 to 10 ohms are typical. We can supply these if you need them. Ordinary 1/4 watt resistors can be used to find the correct value if low power levels are used.

When you have finished the first loudspeaker, set it up side-by-side with the other one still in its original form and compare them using a mono source. You can now hear and evaluate the changes you have made and proceed to mod the original.

3-way loudspeaker upgrade

You can proceed with 3-way designs in the same way as with 2-way. Wire the bass driver (or drivers) direct to the input terminals to drive it full range. Select a test capacitor (say 5µF) to roll on the midrange and adjust the value up or down so that a good balance with the bass is achieved. Then select a lowish value (say 0.47µF) to roll on the treble and listen to the resulting balance. Adjust it up or down until a good balance is achieved. On a 3-way speaker the midrange phase should be the opposite of the bass and treble, so if the bass and treble positives are connected to the positive input terminal, then the midrange positive should come from the input negative (black) terminal. A typical 1970's speaker, the Cambridge R40 using KEF B139, B110 and T27 tweeter needed 3.9µF for the mid and 1µF for the tweeter. Although, when measured, the treble was several dB's down, the speaker *sounded* well balanced! I chose to stick with the best sound rather than the best measurement!

Fuses & Loudspeaker protectors

Remove them from the circuit and throw them away! They are a disaster from a sound quality standpoint. If you cannot relax because you are afraid of damaging your speakers – use an amplifier than is safe with loudspeakers. 'Safe' amplifiers are valve amps and Mosfet amps because they can't produce speaker-damaging D.C. current if they go faulty. The D.C. current culprits are Bipolar transistor amplifiers.

8 Speaker stands

In our opinion the very best sounding stands of all are our Torlyte speaker stands. The next best are stands made of wood. Metal stands ring in time (nearly) with the music and heavy damped metal stands cause tuneless one-note bass and muddy muddled midrange. Use three Cone Feet on the top plate between the stand and the speaker, and, depending on your flooring material, either 6mm or 8mm spikes or Cone Feet between the stand and the floor.

Bare Wooden, Tiled or Concrete Floors

Oak Cone Feet are ideal. The bigger the better, so use the Jumbo Oak Cones.

Fitted Carpet with Underlay

You need feet that will penetrate the carpet to stand solidly on the concrete or wood. Spiked feet are the best solution. If the floor under the carpet is concrete, you need nothing else, but if you have a wooden floor you need some way of stopping the spikes from sinking into the wood. Crosshead screws fixed into the floor are an excellent solution - the spikes can then be located into the screw heads (see instructions below).

Fitting spikes to a wooden floor covered with carpet.

1. Place the rack, cabinet or speaker stand exactly where you want it and mark each spike hole in the carpet. (This can be done by placing Sellotape under the spikes and pressing down so that the spikes puncture the tape.)

2. Insert a screw (use 1" (25mm) No 8 crosshead Philips or Posidrive countersunk screws) into each hole and screw it down. The screws will disappear into the pile of the carpet and become invisible (I suggest doing this while your partner is out!). Each spike will now sit exactly on a screwhead and the result will be a great improvement in bass definition and clarity.

Use three spikes or cones per stand; they are more stable and sound better than four.