

The loudspeaker cabinet.

This part is really a problematic component. It plays its very important role in separating the sound from front- and backside of the units. ***Any attempt to mix them, no matter how, will result in wrong reproduction.***

Further every single loudspeaker unit ought to have its own cabinet. This does it far easier to optimise the summation of sound from neighbouring units, to make that perfect from your position of listening. ***The loudspeaker units must be placed within millimetre accuracy*** and it is important to understand that every change of component in the crossover can have consequences for this placement of units. You can't compare parts of different type in your crossover without adjusting this.

If you compare the area of the sound giving part - the diaphragm - to the area of the front suspension plus the total surface of the cabinet, you have great surfaces that add sound, created by the movements of the diaphragm. These are either harmonic or disharmonic

Onto that you have reflections from the enclosure, as well as from the surroundings near the loudspeaker - floor, walls, ceiling furniture and so on. These are only related to the distances of the reflecting parts.

Oh dear! It's really a noisy part, but worst of all - you are so accustomed to these sounds, that you probably miss them at first, if they are taken away. To my experience through listen sessions it normally takes hours, when listeners are left to themselves to decide. Often the comment 'Where did the music go?' is heard. Luckily the cleaner sound is normally chosen at the end of the session. But there have been cases, where the positive reaction needed a listening at their own equipment first. So it is with listening habits - you will always listen with your own speaker as referee

We unwittingly like a certain amount of distortion and echoes. The amount of this rest - I think - very much on listen experiences from early childhood, where the hearing capacity is built up, but also by the daily experience with sound.

Friends living in concrete buildings prefer apparently a sound not to clear. That is very strange to me.

Newly developed and rather expensive loudspeakers from American and English firms have a strange tendency to spoil the, for me so important, holographic soundpicture, possible to create. ***A singer placed in the middle becomes a voice filling the whole area*** between the two loudspeakers. A mouth organ becomes just as large. For me to hear the sound comes nearer the bad sound from the TV-set often placed in the corner, just louder. Is it possible that that guides our hearing habit? I fear the thought of the coming MTV generations taste of sound.

Another matter that complicates it all - is the simple fact, that we really don't know, what is hidden in the program material. That makes it very complicated, so how to judge at all?

At first you should know how the single instrument sounds in general. Visit a church to hear organ and choir, a piano store to capture the sound of these instruments so difficult to record and reproduce, and use a lot of time on percussion. Voices you should be accustomed with.

Beware of concerts, only from the front rows you will hear some of the instruments sounding near the recorded. Some marvellous recordings are made in the sixties by Mercury, now reissued on CD by Phillips. These are the closest to the sound from the front row, to my experience. There could be others - please! let me know.

For me it is a rather simple matter. I must recognise the instruments playing as an instrument of its kind and keep that impression.

When I hear a grand piano, I shouldn't have the slightest idea of a spinet.

When I hear a clarinet, I shouldn't think of a bazoo. (A primitive instrument distorting the voice, when sung into it)

When I hear a transverse flute I'm not to think on a penny whistler.

My associations must be stable. Thereafter it is a matter of state of mind - if I feel tense and get warm or get talkative- something is really wrong - if on the other hand I get hooked on the event, silent and further start humming, something is very right. Of course there is also the holographic recreation of the instruments and reverberation on the location for the recording. The loudspeaker should show some of that, but it is a step further, as it involves the whole chain of your equipment.

Back to the enclosure. One main problem is to silence the box, which show to be not so easy. It has been common, to build the walls very thick, Trying to get them silent.

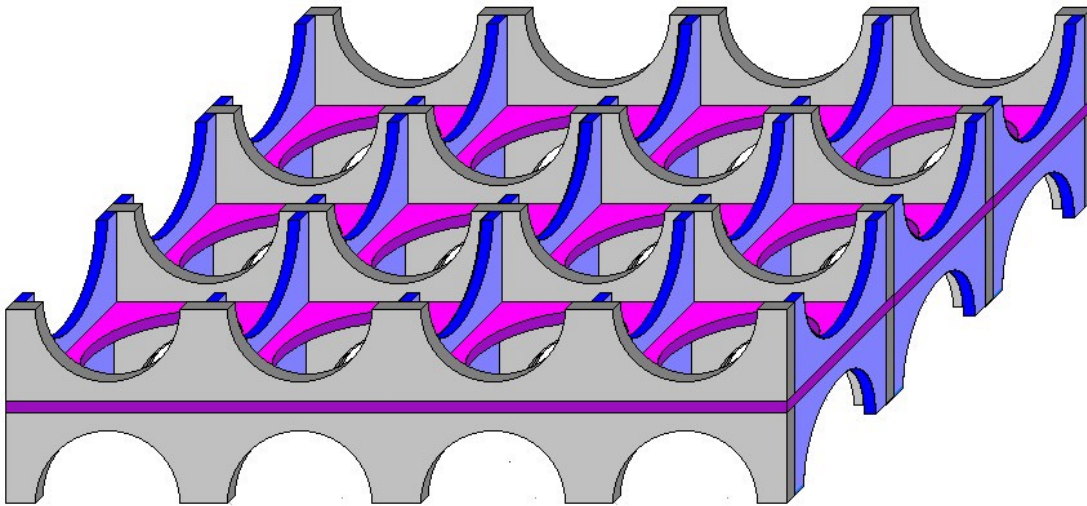
By use of a stethoscope, it is easy to hear, that it don't help enough.

BW with their matrix solution was on the right track, they tried to simplify, but in their new line named "Nautilus", they have returned to that inner construction that can be improved further.

If you are a person with practical skills for woodworking, you should follow their way, just do it even better. The result and only the result should count, even if it is troublesome to make. The most annoying thing of all, building loudspeaker enclosures, is the uncertainty of the result. If I had kept all wrong doings through the years, what a pile that would be.

Below a picture of the matrix-structure from which a mould could be made. It should be possible to use a cheap mix of material left over from production and plastic, to form casting easy to adjust. By stabling of these the inner matrix structure could be made simple and easy.

By inspection of the picture you can see how it is built from fibreboard.



Working with matrix, a most interesting result is the importance of the glue. If the matrix is built from smaller parts of fibreboard and hardening glue is used, then the mechanical transfer to the walls of the enclosure is good, and it shouldn't be. You must use a glue, that when dry, must keep the elements in place, but at the same time allow the vibrations to be transformed into heat. Modern mixes of bitumen and plastics used for tarring roof, having - when dried out -an elasticity of up to 400% - can be used with excellent result. In Denmark it is sold under the name 'Isopunkt' but it is produced in Germany. This stuff has the most peculiar properties used for audio purpose, which will be treated later. The glue for assembling the enclosure itself, should be the normal used. Another interesting property, the matrix to have, is its behaviour as a lowpass-filtering device. Thereby the dampening material can be kept to an absolute minimum and for that the old day's kapok or wool should be considered again, it is far better than modern synthetics and can easily support itself in these small chambers.

Some friends have taken the full step and removed all damping material. That I feel to be too drastic, but problems with resonance can be seen by measurement of impedance. This matrix construction, which I have used for many years now, can be said to consist of little boxes with a big hole in all six sides. By stabling the whole volume is filled. (It is built in a simpler way of course)

The main thing to decide is the size of the little box, and the size of the holes. This has to be guesswork - not too small and not too big. I have tried to get it calculated, but they gave up. Following my experience you think a cross on the unit in use. to form four boxes behind the unit.

The two sides should be about that half diameter, selected to differ sufficiently, the third side should be selected sufficiently smaller or bigger than the two others.

The size of the holes in the construction is determined from the box formed behind the loudspeaker (4 small boxes). The total area of the 12 holes leading out from these boxes should exceed the working area of the loudspeaker. If the holes are too small, this little box will cause a rise of impedance just over the resonance frequency. Then you must make the room deeper up to 6 or 8 small boxes.

The curvature of the impedance, measured on a unit, tells you a lot. If you can't compensate it, around the resonance frequency, to exactly DC-resistance using a LCR series in parallel with the unit, then something is wrong with either the box, the back suspension of the unit or the cabinet is not tight. These can form variations on the graph, where it should be smooth. *The irregularities must be removed, as they will effect the passive filter function.*

The enclosure is of the closed type, which I must admit I prefer must be sized to keep the total Q under 0.5 or even 0.4. New experiments have shown that the term closed is to be taken not too literal. By inserting an airflow resistance, big in size and very low in airflow, the reproduction of the sound is changed in a positive way. Again the impedance tells you how far to go. You must never end up with a curve like bass reflex, that of course only if you don't want to build such a cabinet. It is much more a question of a mild softening of the spring ability of the air closed in, than to get sound from the dampened opening.

By this method of construction the cabinet is silenced effectively except for the front and the backsides. These pieces are coupled to each other and the only easy way I know of to dampen them, is to face them with soft 10 to 30 mm. felt. If you would like to go to the extreme you should build the magnet assembly into the matrix to get its vibrations lesser coupled to the front of the cabinet, and use the cabinet itself as bearing for the rest of the loudspeaker, but that is hard work.

By covering the front you meet another enemy - high sound level and reflections - and even if the felt may feel soft, it probably is not soft enough.

The Danish engineer Poul Ladegaard has shown that rock wool or glass wool will meet the demand and even hide the edges for the loudspeaker to see. It can be covered with open cloth, but use measurements before and after covering, to be sure the cloth don't disturb and don't use glue, that will disturb for sure.

The loudspeaker units

This most intriguing part is the main part of them all, as it is through this the electrical energy is transformed to sound.

As a DIY-man I also fabricate that part myself, unsatisfied with what's on the market. You will find a deeper treatment and a summary about that in "building to the limit" This is probably of no interest for you, but you may be interested in some findings - how to improve the behaviour from a normal unit.

Generally the bass units for now are manufactured for use in bass reflex cabinets, and are therefore built to withstand rough treatment. That often means that resonance frequency is high, and that the grip from the suspension around the voicecoil is tight and not linear causing distortion. It secures the membrane from leaving the cabinet, when deep bass is played at high level, as the bass reflex cabinet doesn't help below its resonance frequency. For that to be, the closed cabinet must come into use.

With closed or nearly closed enclosures the suspensions should be very soft. Personally I take the rear part away and substitute it with a new, build from thin woven nylon wire. Again it is tricky to make, but details can be found under "rebuilding rear suspension". You can soften the suspension by deforming it with your thumb, or let it work over

night supplied with a very low frequency. Often the volume under this suspension forms a little cabinet causing a rise of impedance. Then you can burn holes in it with the tip of your soldering tool. Take care that you don't spoil its capacity to centre the voicecoil. The diaphragm is often too light or stiff, why the level rises towards the treble. The narrowing of sound field should cause a rise on 6 dB, dependant of the size of baffle, but no more, and the increase must happen in a gentle manner.

It is strange with these opinions. The diaphragm is best when it is light and stiff, they say. But that is wrong. The weight must be balanced with the magnetic force present. The stiffness must not give rise of level at first break up frequency, so the stiffness must be softened without the main goal of stiffness is lost. It is always a question of balance, and is far more complicated than thought of.

To make it heavier the earlier mentioned tar 'Isopunkt' is very good. It has a peculiar ability to clean up the sound as well. An example is the polypropylene diaphragm, which can be said to sound a bit like a credit card. Smearing the surface with Isopunkt do change this sound. To judge the amount of tar, you must give it time to dry through, preferable under light or the sun to harden the surface. Should you regret, it is to be removed using solvent. Remember - out in the open to do that.

The dust cover is a part normally impossible to live with. If you want good reproduction you must silence that in one way or another. I personally remove it and prolong the centre tap (known from Lowther), but there may be other solutions for you to find, if a problem arises. (Part of balls for table tennis can be used instead of the normal used)

The front suspension can give cause to variation in level as in impedance - 8 inch just under and 6 inch just over 1 kHz. You probably have seen, this problem being tried cured with a line of glue on the inner folding of the front suspension. If you observe a loss of level and rise of impedance in the area mentioned, it can be fixed by increasing the amount of glue, to erase this folding. It's a special kind of glue, as it has to stay soft, but not flow. If you have problems getting it, you can contact me.

Some of my latest research deals with this part of the loudspeaker. I'm trying to remove it at least from the bandpass loudspeaker, where amplitude is small. By these experiments the front suspension has shown its ugly face, of how deteriorating it is for the sound. It is a tricky matter to solve, but there are ways - so much I can say now. A prototype is nearly finished, and I look forward to listen to this unit, so near the theory for dynamic units.

The new BW unit follows the same idea. To my ears something is very wrong with their solution. I'll look forward to measure that unit, if it should be possible. I'm told that it shall play hundreds of hours. For now I can't stop thinking on the Lowther unit when I hear it. But my view might change.

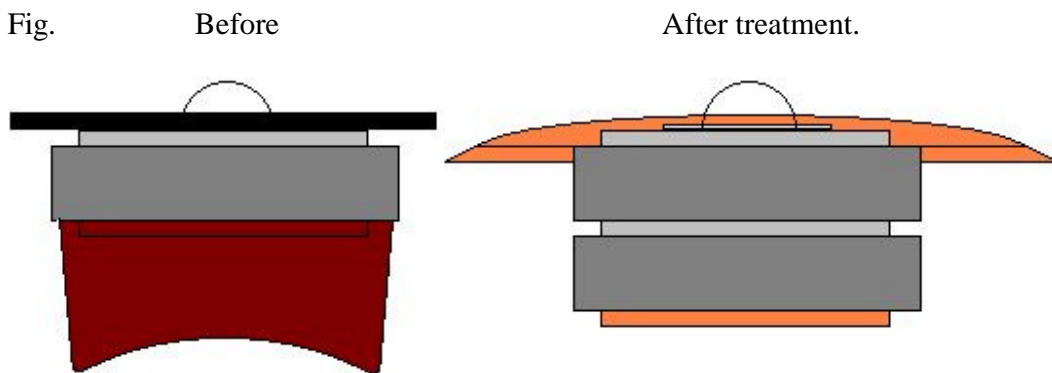
The variation in loudspeaker units, used around the world, makes it impossible for me to give more guidelines, but the tar 'Isopunkt' is a miraculous stuff.

The units for the middle with its very high demand on range and lower demand on efficiency are still not solved to satisfaction. The diameter of the diaphragm should be between 5 and 7 cm and the unit must have a very low resonance frequency. The best unit I have found until now is 4-203/25 HEX from the German factory ETON, but it needs deep modifications to sound right. Then it really is marvellous. It is strange to me,

that this factory also has taken 5-80/25 HEX and 8-470/32 HEX out of production, they were the good ones. Why??? The rest of their program is in my opinion a classical example of how not to do it.

Concerning treble units, the dome construction is widely used. I don't find that to be the best, but they are the treble in use. They are most delicate and sensible, so don't touch their diaphragm. Domes often have a problem built in, if there is a hole through the centre pole, leading to a volume behind the magnet. Tap on the cup to form this volume. This sound comes through when playing. Some of them sound really awful. Personally I take that cup away and seal the hole, gluing a suitable coin on the backside of the magnet to cover the hole. If you want to keep the volume behind, you should form a wooden cup with a sufficient number of supporting pins to stabilise and dampen the bottom of this cup or better add more magnets and use their inside volume instead. Often another problem related to immediate reflections on the mounting ring occurs. What you can do, to see what I mean, is simple. Listen to and measure the unit, mounted in a free front plate placed horizontally. Remove the mounting ring and listen and measure again without. You should be surprised if nothing happens. If you can see no different, then rest with ease.

To my experience this mounting plate gives an unpleasant sounding rise of level around the most critical 1.5-3 kHz and can further create some disturbances around 5 to 6 kHz. Without this ring plate you have a problem of mounting, with this plate you have a problem of sounding.



To make experiments you should make a copy of the plate in speak from fibreboard, and work with that. It is the slope of the front of this plate you should change from a plane to a kind of conical or spherical cap to direct the reflections away. It is further wise to lift the dome free from the baffle. You can add another plate to fit around the front iron part of the magnet assembly, or use that alone, if the diaphragm is mounted on the magnet. In this way it is possible to solve that problem. Furthermore you should dampen the reflections from the baffle around the unit. Exactly how is so dependent of unit and cabinet in use. You have to experiment, by heavily use of measurements. I must here direct your attention to the screws used for assembling the unit. They are

normally made of steel, and you should try to listen, when the screws are made of brass. Further you should inspect for irregularities on the surface just around the dome, screw holes, holes in screw and other irregularities. These must be softened out. The surface around the dome itself must be smooth to avoid unwanted reflections. It is strange to me that manufactures of such units neglect these faults, so easy to correct. If you still have gaps in your frequency response, you could try to make a ring with a diameter equal the $\frac{1}{2}$ wavelength of the gap in amplitude, and place it around the unit. The best material for this ring is a very soft string of foam rubber used in tightening "Eternit" boards for roofs.

This was the mechanical possibility - electrically you should focus on the break up problem to give rise of level around 10-13 kHz on one inch domes. This can be corrected with a LCR circuit in series. Watch out to use very, very good components. Especially the coil with its low inductance value around 20 to 40 micro Henry must have extremely low DC-resistance. This correction has great influence on the holographic picture. Heard it in work once you'll never listen without.

There will come constructions of loudspeakers, 2 to 4 ways on this homepage. But to do that, I must find units, having a high degree of uniformity. Otherwise you wouldn't get the results I have worked so hard to attain to. Nothing less than perfection within the limits, set by the units, components and cabinets used, should be accepted.

The Danish factory "Vifa" is well known for exactly that uniformity, and later year's developments on a new series from that factory can by simple means be made very good by measuring. But to my ears they somehow keeps the inner detail from music within themselves.

Also "Scan Speak" units should be of interest in treble and bandpass preferably their older constructions. There should be others - if you know of good units that measure alike, and still are in production - please! Let me know. Good constructions are strangely taken out of production

The room within to listen.

This part could be seen as difficult to correct, as it normally also is the living room. Often it is heard, when loudspeakers are demonstrated, that the room causes problems with the sound.

Nothing could be more wrong, it is always the loudspeaker which is the culprit, especially with people present. It would be the same as to say my piano or guitar can't play, because the room is bad.

The room can have an unpleasant reverberation, but for that to be it must be empty, and living rooms seldom are. We fill them with carpets, furniture, pictures and so on, for us to feel well in the room. We wouldn't like, having trouble understanding each other speaking.

If you like to stay in that room, you also can play music there. I don't say that you can play loud, as that always will create problems. And I don't say that people from outside will find the reproduction in order, but you can.

Many homes I have visited have had the most stylish and fashionable living room as room for listening. Where do they like to stay most of the time? - In the kitchen - well then their loudspeakers should be there.

Also hi-fi nuts can have the most peculiar behaviour. They use a lot of money on their equipment, and their room for listening is often nearly empty. If it is so to give room for a crowd of listeners, I can understand it, as their presence will change it all dramatically. In the fight between eyes and ears the eyes normally wins - it shall look nice and in order, that is the starting point. So how to get the best possible sound in a nice looking living room with modern furniture from nice looking loudspeakers.

It is mainly a question of loudspeaker quality, and magnet power.

When listening, the first sound reaching your ears, will always be the direct sound followed by the reflected sound created by the surroundings and their coefficients of absorption.

The reflected sound will build standing waves in the bass frequencies. The bass unit feels these, as it also serves as a microphone. That will create rise of impedance at these frequencies, whereby the bass loudspeaker will lower its output. It helps further if the amplifier and filter have so low impedance that it can serve as short-circuit.

The first reflection starts on your loudspeaker cabinet. They follow the direct sound with so short a time span, that the direct signal so to say is mixed up with reflection. Thereby what should be direct sound, for the brain to use, isn't. As an analogy could serve the picture on the old days televisions with its shadow pictures - it is much like that just with sound.

Many modern loudspeakers have the cabinet front reduced to nearly nothing, as for example the BW Nautilus. Is that the right way?

I think not - the units are thereby forced to work in their upper band, where they have problems, they so to say have lost foothold for their lower band, which gives a loss of 6 dB, where their highest quality lie.

That foothold is the baffle itself, to direct the sound towards you, and reduce its messing around.

It is also important to mark that loudspeaker units are developed to measure well mounted in a large baffle. Not in the small boxes so commonly used.

It is of course a question of taste.

If you want the same sound, nearly wherever you are in the room, you should mainly listen at and create reflected sound.

If you want to get the music presented as a sound stage almost visible, you should fight reflected sound, especially that from your loudspeaker enclosure.

Concerning the room, your brain has no difficulty to recognise and compensate for the fingerprint that makes on the event. It is trained, to do exactly that at normal conversation level.

You could place two persons you know, at the place for your loudspeaker, and your self on the preferred place for listen, and start a discussion. You will then either learn your room, or you will remove the persons to a place, where you better understand their speech. There you should place your loudspeakers.

The main work should be to mould and silence the baffle in the right way, for the direct sound to be mostly that. The single units must further work together in phase. If they don't work in phase, the level at the dividing frequency have to be raised 3 dB, to form the correct vector summation in the direction of the listener.

That is however catastrophic for the instant reflections on the cabinet and the other loudspeaker units. Not to mention the reflections in the room of parts of sound, that shouldn't be there at all.

I know very well, that when a multi way loudspeaker is calculated in the aspect of effect, that will be better, when these out of phase filters are used. But I have worked so many years with them that I surely can say, "*Linear effect is not the right approach*". You will always hear the single units, and that you shouldn't.

The task for the loudspeaker to fulfil is to transmit the information received by the microphones further to you, with smallest possible disturbances. Therefore the area behind, between and around the loudspeaker should be silent with no reflections at all. These reflections include the cabinet itself. Its beautifully veneered or painted sides are also reflecting sound.

You could try to hang a woollen carpet or a bath towel over and down these sides of the loudspeaker cabinet and listen. I'm sure you will be surprised, the improvement to be gained by that simple operation.

In real life with wife and nice looking living room none of these proposals are possible permanently. But to get a sample of, what you could gain in sound quality, try to place your loudspeaker much nearer to you, as near as let's say 1 to 1.5 m, and as far away from the walls as possible. Then listen with and without the top and sides dampened, and if your loudspeakers are just reasonable good, you should be able to see much of the sound stage recorded.

If your loudspeakers have a stationary place you should work more with the balance of sound from the loudspeaker than your room. You could also try to tilt your loudspeaker backwards, if all units are placed in one plane at the front, to extend the runtime for the treble.

The sound character of our room is easily heard by clapping your hands.

If you have flutter echoes as common in concrete buildings, or your room sings you can't play with realistic level without some harshness in the upper middle band and lower treble. To fight that there are no simple way, but curtains, carpets, wall decoration with smaller carpets, books yes nearly anything to break the regularities of the room can be used.

With modern loudspeaker you don't have the possibility to vary the sound level of the treble directly. It is also modern to have far too much treble. The sound level should in listen position from 225 Hz softly be dampened to -8 dB at 20000 Hz. Such a measurement also includes the room. The bass response should also slowly be dampened from 225 Hz to -4 dB at 20 Hz.

This is not new knowledge, Bruel and Kjaer recommended it back in the seventies, based on a row of listening tests, but it is strangely forgotten. To my experience it is a very good starting point, to regulate on to reach your personal taste. Just don't be too hasty in your judgement, it takes time to change old habits.

Concerning bass I know it will be a hard battle against normal opinion formed from high Q, bass reflex and totally wrong level of bass in the room to listen. But I will give it a try.

Creating space to the back wall normally does the regulation of bass, but the real advantage is the prolonged time to back wall reflections, that gives your brain a chance

to distinguish between direct and reflected sound

The problem with bass is mainly a matter of magnet power, wrong cabinet principle and a widespread opinion that bass is not to regulate - It sure is, done right.

The bass response from your loudspeaker, working together with the resonance and bass decay in your room, has to be balanced to achieve the above mentioned level, far below hearing capacity (at high level even lower than 16 Hz). It has a positive influence on transient response.

How to do that is a longer story, best told and demonstrated in practice, so you must look for that in "Building to the limit"-bass response.