

Redefining sound

Sometimes the most ground-breaking ideas and discoveries come from the simplest questions. It's true for writing and composing music, and it's equally true when it comes to building and designing loudspeakers.

When the pioneering composer Tod Machover began to reinvent opera with his new work *Death and The Powers*, he asked himself three questions. Does what we see affect what we hear? Can a stage also be a musical instrument? Could the main character of an opera be the stage itself?

When B&W set out to create the world's best loudspeaker, we asked ourselves the same kind of fundamental questions. Is it possible to create a theoretically perfect speaker – one that produces next to no distortion? Does a speaker have to be a box? If you remove the box, what would a speaker look like? More importantly, what would it sound like?

We were about to find out.



Tod Machover is widely regarded as one of the most innovative composers of his generation. He has been professor of music and media at MIT Media Lab in California since it was founded in 1985, and is the creator of Hyperinstruments, a new type of intelligent, computer-augmented musical instrument. His new opera *Death and The Powers* will premier in Monte Carlo in September 2008 before touring worldwide.

Find out more about Tod Machover at the Society of Sound, B&W's online forum for sound innovators and enthusiasts. Visit www.bowers-wilkins.com/sos



Creating an icon

Like every design classic, it takes a little getting used to at first.

For a start, there are those long, tapering pipes protruding from the back. Then there's the curving, spiral form of the body, and the glossy, almost liquid finish. Even before you listen to it, it's obvious that the Nautilus™ is no ordinary loudspeaker. That's because it's the product of no ordinary speaker manufacturer.

B&W has long been regarded as pioneers of the art of speaker design. Our research and development lab in Steyning, commonly known as the University of Sound, was the first facility in the world dedicated exclusively to analysing the reproduction of sound in all its forms. We see it as a mark of our success in this field that our speakers are used as standard in the world's most demanding recording studios.

The Nautilus is the end result of the most ambitious research and development project B&W has ever undertaken – to create, as near as possible, the perfect loudspeaker.

The brief was to do whatever was necessary, however unconventional, to make the best loudspeaker anyone had ever heard. Over the course of an exhaustive five-year development programme, that's exactly what we did. Every component, from drive unit to cabinet enclosure, was re-examined and re-invented. Every pre-conceived notion of what a speaker should be was challenged. And the rulebook for speaker design was torn up and re-written in the process.

So the Nautilus might look a little unusual. But listen to it, and it all makes perfect sense.

At high and mid-range frequencies, sound tends to travel in a beam, front and back. In the Nautilus, exponentially tapering waveguide pipes (also known as transmission-line pipes) are filled with damping wool to absorb all unwanted rear radiation of sound. B&W engineers used computer-aided design techniques to ensure the mathematical accuracy of the wave-guides.



The horn principle



B&W engineers chose rare earth magnets for the Nautilus's tweeter and midrange drivers. The magnets are made from neodymium, iron and boron and the hollowed-out pole piece is unique to our top of the range loudspeakers. This creates space for rearward-travelling sound waves to pass through the magnet.

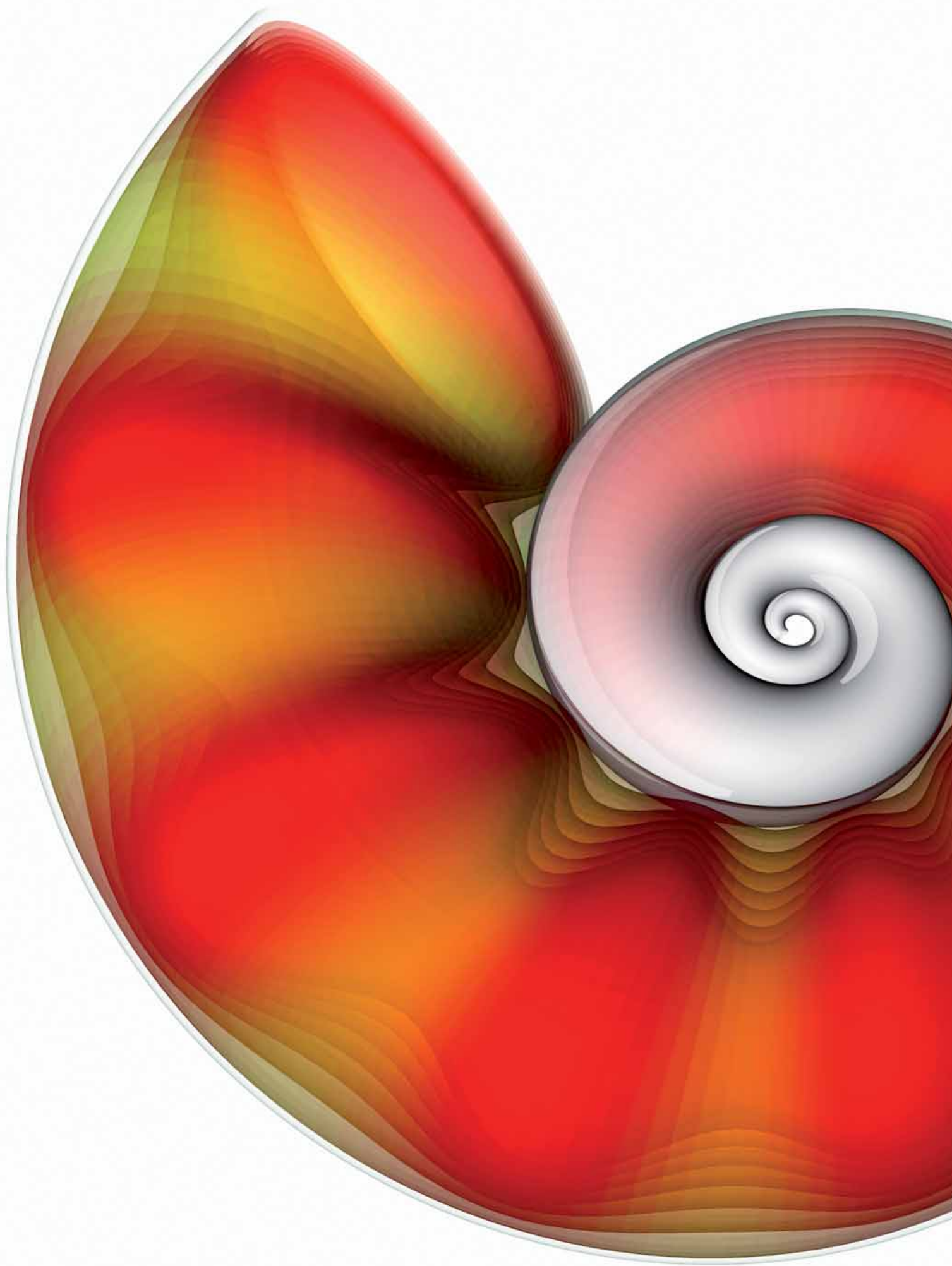
The horn has always been one of the simplest, most basic forms of sound amplification at our disposal. Try cupping your hands around your mouth and saying something. Easy, isn't it?

So far, so straightforward. But then we discovered something interesting. Reverse the shape of the horn and the opposite happens. Instead of amplifying sound, it vanishes altogether.

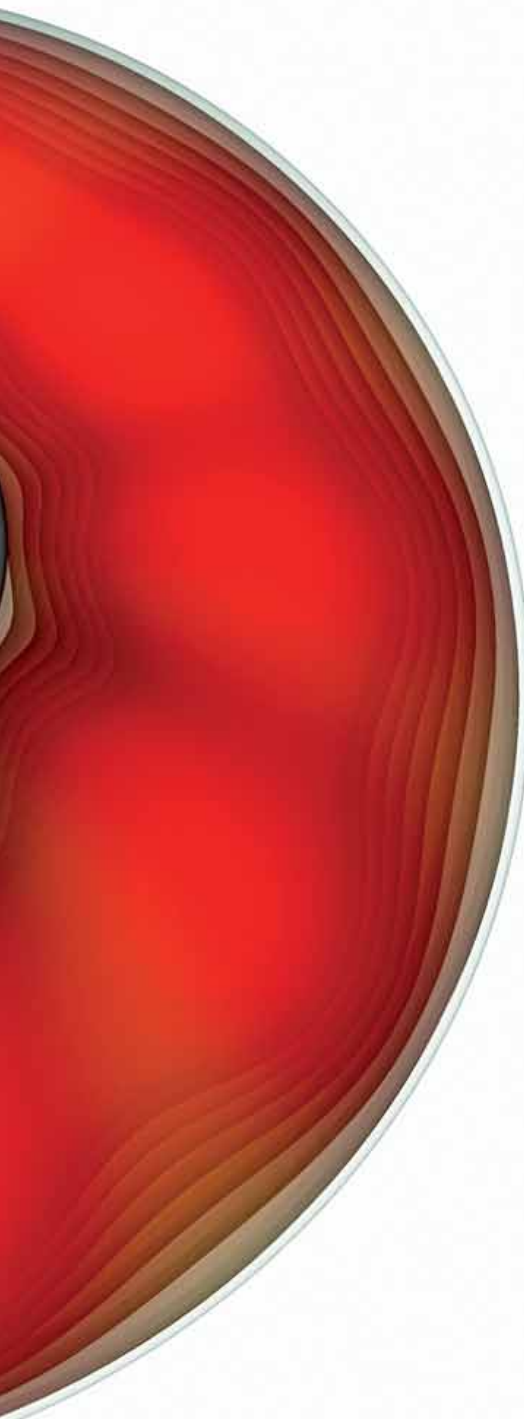
Speaker designers have always been faced with the problem of colouration: unwanted sound radiating from the back of drive units, resonating within the cabinet and mixing with the sound from the front. With the inverted horn, we found the solution. By enclosing each drive unit at the front of a specially designed tapering tube, rear sound waves are channelled, absorbed and dampened until they virtually disappear.

The result is speaker with the purest possible sound coming from the front. And none at all from the back.





Learning from nature



At B&W, we firmly believe that the form of a product should be dictated by its function. The only problem is that function occasionally seems to demand a form that makes no practical sense.

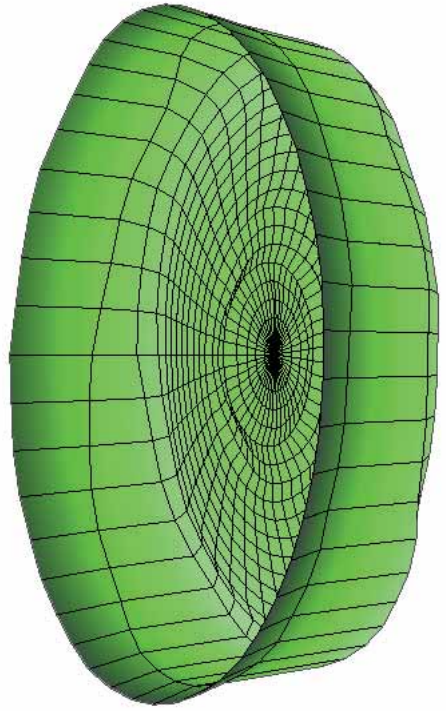
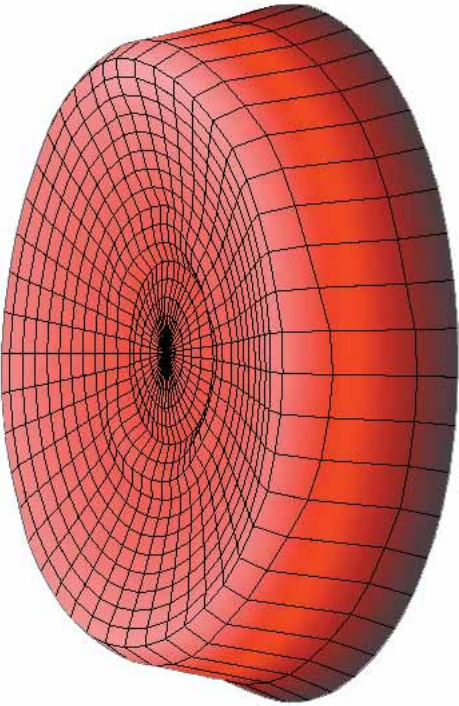
We had already decided that long, tapering tube shapes were the best possible enclosures for the Nautilus's drive units. That raised a dilemma. The length of each tapering tube needs to be proportional to the size of the drive unit it encloses – and in the case of the Nautilus's 300mm bass unit, the pipe would have to be around three metres long. Not exactly ideal for a recording studio, let alone a living room.

So it was back to the drawing board – and, in their relentless pursuit of perfection, the B&W research team had another stroke of inspiration. Experiments showed that bending the pipe into a continuous curve would save space without compromising on performance.

The spiral was born. An organic form inspired by nature, but derived from pure science.

In B&W tests, a vibrating ball immersed in water produced outward-radiating waves, similar in pattern to sound waves, which vary in reflection according to the shape of an enclosure. A square-shaped enclosure showed a high level of interference, while a curved, spiralling shape produced no discernible interference at all: the waves flow along the tube without reflection.





Perfect pistons

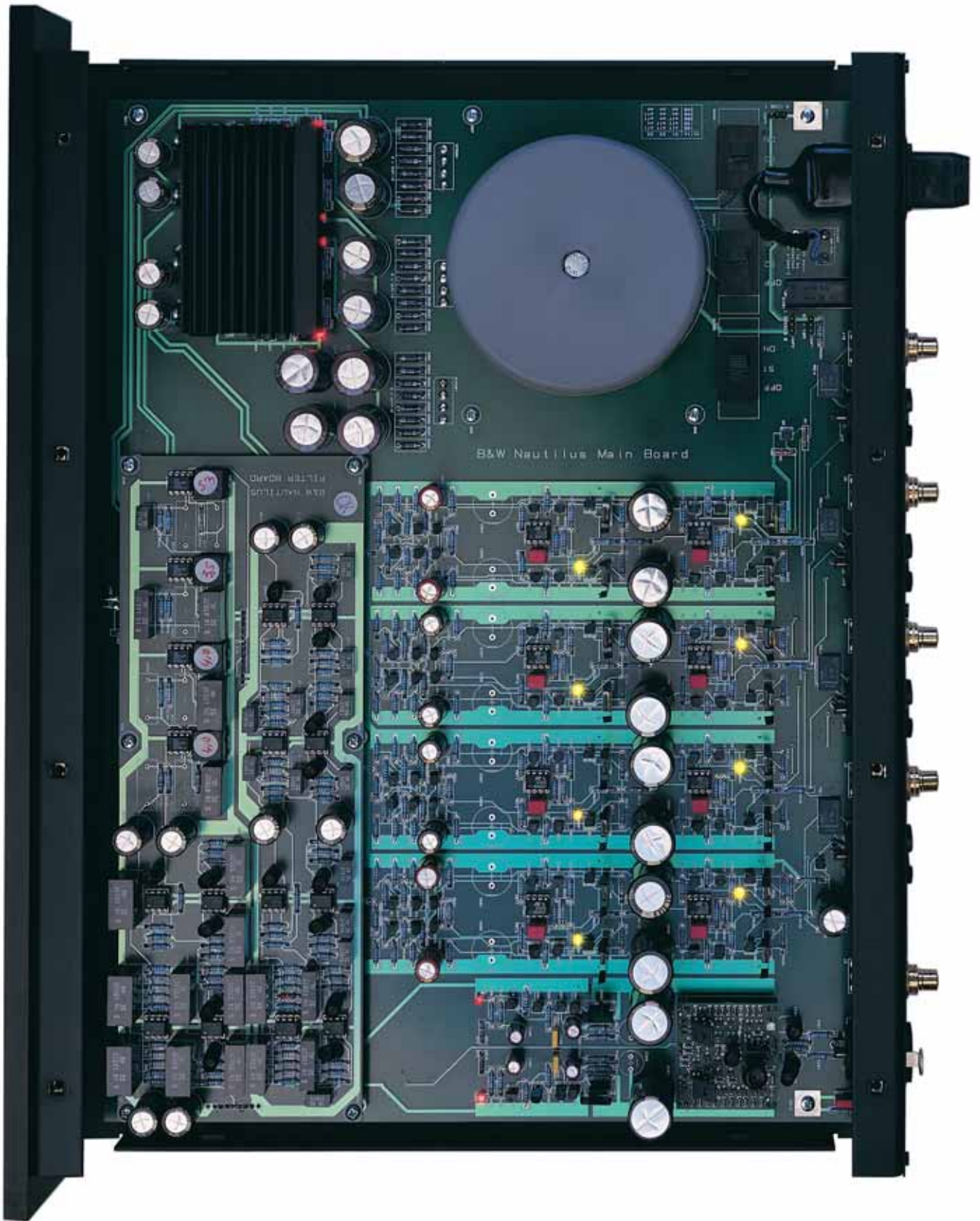


B&W's research and development laboratory in Steyning has helped to develop some of the world's most advanced measurement and forecasting techniques for loudspeaker design. Our system of laser-doppler velocimetry, for example, allows us to measure the pattern of vibration in Nautilus cones and domes to 1/3000 of a millimetre.

Drive units are the over-worked multi-taskers of the speaker world. Even in the most advanced top-end speakers, each driver must help to reproduce a wide range of frequencies, taking over responsibilities when their partners fail to cope. As a result, responsiveness can be affected. Music sounds less detailed, less vibrant. Live recordings sound less, well, live.

Not so with the Nautilus. The unique active crossover design of the speaker frees each of its four drive units to operate purely within its own frequency band. In other words, they do only the job they were designed to do, without having to share the burden of work with the others. This allows us to use materials that are stiffer and more accurate than those used in conventional speaker drivers. Built from anodised aluminium and decoupled from the cabinet with silicone rubber O-rings, Nautilus drivers are designed to operate as perfect pistons: highly mobile, rigid and totally precise.

Thanks to the accuracy of its drivers, the Nautilus is able to create a seamless, three-dimensional sound stage, and an uncannily lifelike sound quality.



Active performance



High frequencies

Two domed units of 50mm and 25mm in diameter handle the 880Hz-3.5kHz and 3.5kHz- 25kHz ranges respectively.



Mid-range frequencies

From 220Hz to 880Hz, the Nautilus uses a 100mm flat-fronted unit to avoid the gentle cavity resonance found in conventional cone units operating at these frequencies. A rare earth hollow pole magnet allows rear radiation from the diaphragm to flow freely down the wave-guide pipe.



Bass frequencies

The 300mm bass unit uses a 250 micron one-piece aluminium cone / centre dome to handle frequencies to beyond 1.5kHz. A massive 9.5kg magnet with a 100mm voice coil acts as the motor for the drive unit.

Dedicated audiophiles know that the very best speakers sometimes make demands of their owners. A lot of floorspace for one. Perhaps some furniture rearrangement. Expensive cables. Even so, you could be forgiven for wondering why the Nautilus requires not one, not two, but no less than five separate amplifiers. Excessive? We beg to differ.

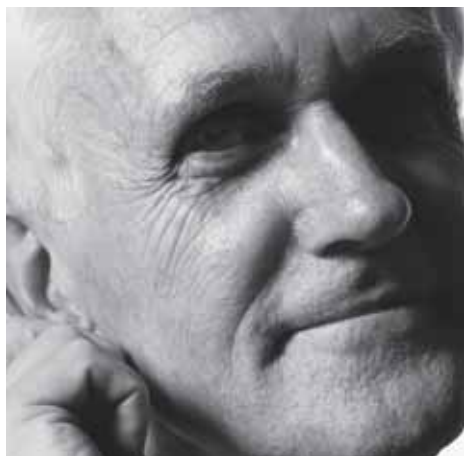
The Nautilus needs several amplifiers because, alone among B&W speakers, it uses an active crossover circuit. This filters and splits the signal into individual frequency ranges, which means you need one pre-amp to produce the signal and four stereo or eight mono amps to power the drive units.

Why use an active crossover system? The simple answer is that it talks to the drive units more clearly. Because each driver enjoys a one-to-one relationship with a dedicated amp whose signal exactly matches its requirements, the Nautilus achieves a level of accuracy and detail throughout the entire frequency band unmatched by any conventional passive crossover speaker. Phase and time between frequency bands are almost perfectly aligned, meaning that you'll be hearing sound that's crisper, clearer and more vibrant than any you've experienced before. Which is worth a few extra amplifiers to us.

The Nautilus's active crossover networks are individually fine-tuned to suit listening room requirements. Because B&W crossovers are carefully matched to each drive unit, both driver and network can be updated to keep pace with new refinements.



“It just had to be done”



Dr Peter Fryer joined B&W in 1985 as head of research. As well as helping to develop the Nautilus, he was instrumental in advancing B&W's work in using laser-doppler velocimetry to visualise the vibration patterns of speaker cones. He is also an expert in techniques for predicting the behaviour of acoustic systems.

Peter Fryer, one of the architects of the Nautilus, talks to B&W senior product manager Mike Gough about the ideas and inspiration behind the world's most iconic speaker.

Peter, perhaps you could begin by painting a picture of the speaker art before you began working on the Nautilus, in terms of what was happening both at B&W and in the wider industry.

At B&W, we had been pursuing a track originally forged by the Model 801. With that speaker, we brought together the power and bass extension of big speakers and the superior imaging of smaller ones. Before the 801, most moving coil speakers had simple rectangular cabinets that just varied in size according to the diameter of the bass driver and its operating volume. Few companies had explored the possibilities of having different size enclosures for different sections of the frequency range.

Most other speaker companies were following the moving coil route of speaker design, but one or two were carving a niche in other areas. Electrostatics, for example, were always associated with low levels of colouration. We ourselves had made a hybrid speaker, the DM70, using an electrostatic module for mid and high frequencies and a 12-inch driver for bass. But we eventually ran up against the reality that, if you drive electrostatics hard at any frequency, they tend to arc and burn through the diaphragm. Either you suffer breakages or you have to limit the output. I suppose that's the main reason that electrostatics have always remained a niche product.

So whose idea was it to start on what ended up being a very long project?

It came right from the top. You have to understand that John Bowers was totally obsessed with perfecting loudspeakers. I won't say it's all he lived for, but it came pretty close. He hated to be bested by the competition and wanted to make a big leap forward in the art. At the time, he knew his cancer would probably prevent him from seeing the fruits of the project and, sadly, this proved to be true. But that didn't matter. He wanted his company to start digging thoroughly into all aspects of speaker design and come up with something very special. It didn't have to make money or sell in great numbers. It just had to be done – a bit like climbing Everest.

Did he set a large team on the project?

Quite the contrary. He gave the project to one engineer with the very simple brief of looking into everything and doing what was necessary, however unconventional, to make the best speaker anyone had ever heard. When John died, it became my responsibility to oversee the project. I gave a few minor adjustments to the tiller, but it was really Dick's [Lawrence Dickie's] work. He and [former B&W director] Robert Trunz got involved in virtually everything, from acoustic experiments, to making prototypes in the model shop, to talking with suppliers and sub-contractors.



Can you talk us through the main elements of the design in terms of how they get close to John's idea of a perfect speaker?

No other speaker had really coped completely with getting rid of all the sound that comes from the back of drivers. There was always some residual energy escaping to mix with the direct sound from the front. But with the distinctive design of the Nautilus, with its long, tapering tubes at the back, we've been able to eliminate this kind of colouration almost completely.

Not that the use of tubes or pipes is new. People have been playing with so-called labyrinth or transmission line speakers for many years, but they have never done it properly. They have always folded the pipes in rectangular cabinets, which causes energy reflection, or made them too short to be totally effective in absorbing the energy completely. When done correctly, however, it's a very powerful technique.

The solid imaging stems mainly from the frontal aspect. Like the 801, the enclosure narrows from the bass driver up to the tweeter and that gives a wide, and perhaps more importantly, more consistent dispersion of sound as the frequency varies.

A good deal of the project time was spent on driver design. You will notice that all the diaphragms, be they cones or domes, are of aluminium – stiff enough not to suffer breakup in their working range and a fair bit above it too.

Why is the Nautilus a four-way speaker?

For any design to be successful, you have to apply technology appropriately to the situation. It is no accident that the Nautilus is a four-way design. Dic found out in quick order that while drivers with stiff diaphragms operate superbly, they have a fairly limited bandwidth and tend to resonate after the first breakup frequency. But with a four-way design, you have all the advantages of perfectly stiff drivers, while overcoming any negative side effects.

Finally, Peter, what has been the long-term effect of the Nautilus project?

To some extent or other, you will find elements of the Nautilus design in virtually every product we make today. It's that important. I think it's a tribute to John's original foresight that, aside from wanting to create an icon, he appreciated how that knowledge base could benefit other products.



Mike Gough joined B&W's research and development department in 1989 after designing speakers for Goodmans and KEF. He later moved to the marketing department where, as senior product manager, he is involved in all aspects of new product creation. He holds degrees in physics and applied acoustics.



Forming the shell

Raceprep knows a lot about building strong, moulded enclosures. Hardly surprising for a company that specialises in making fibre-reinforced bodies for Formula One racing cars. So when we were looking for a manufacturer who could bring to life our challenging concept design for the Nautilus, they seemed the obvious choice.

The beautifully curved, seamless exterior surface Raceprep built for the Nautilus is formed from 10mm-thick, glass-reinforced ABS compound. Extremely stiff, solid and durable, with no sharp edges to diffract sound, it's an ideal shape for a speaker enclosure. The cabinet is given even greater stability by a polished terrazzo-type plinth block, weighing in at a hefty 50kg.

The same attention to quality and detail has been paid to the surface of the Nautilus's shell. The high-gloss, pearlescent finish is the result of the painstaking application of 12 coats of lacquer containing aluminium and mica particles, and a baking and curing system specially formulated for B&W.

A skilled paint finisher applies a final coat of ultra-violet protective lacquer to the Nautilus enclosure. It takes nine days, including curing time, to make just one shell.





Unlimited colour

The Nautilus is a truly unique speaker. But if you'd like to make your own set even more individual with a surface colour that matches your personal specification, and you don't mind waiting a little longer for your speakers to arrive, we'd be happy to oblige.

Traditionally, the Nautilus comes in three off-the-shelf colours: silver, black and midnight blue. However, for the artistically-minded among our customers, we also offer a special service that can provide you with a speaker in any colour you like.

The possibilities are endless. Always dreamt of owning Nautilus speakers that exactly matches the colour of your car? Or your favourite brand of nail varnish? Want to give your speakers a multi-hued, ChromaFlair sheen? Who are we to argue? Get in touch, explain what you're after, send us a colour sample and we'll make it happen.







Manufacturing excellence

When you buy a set of Nautilus speakers, you're not just buying an icon of speaker design. You're purchasing the manufacturing expertise of one of the most highly skilled, dedicated workforces in the world.

B&W's manufacturing team uses a mix of hand-assembly techniques and semi-automatic production processes to make drive unit components for the Nautilus. While our care and attention to detail can make for a longer manufacturing process, we think it's the best way to ensure that we consistently reach world-class levels of quality.

For example, all B&W voice coils are wet-wound with high-temperature resin and then baked in a special oven to ensure enhanced performance and durability.

Some manufacturers see wet-winding as unnecessarily costly and time-consuming. At B&W, we believe it's essential for achieving the kind of quality and reliability for which our loudspeakers are renowned.





Final rehearsals

Even the greatest performers need a sound check before they take the stage. The Nautilus is no exception.

During the manufacturing process, we subject each speaker to the sternest examinations imaginable. We run tests for a whole range of parameters, including sensitivity, harmonic distortion, polarity and impedance. We test every drive unit individually across the entire frequency field, far beyond the boundaries of human hearing. And then, when the speaker is assembled, we test them all over again.

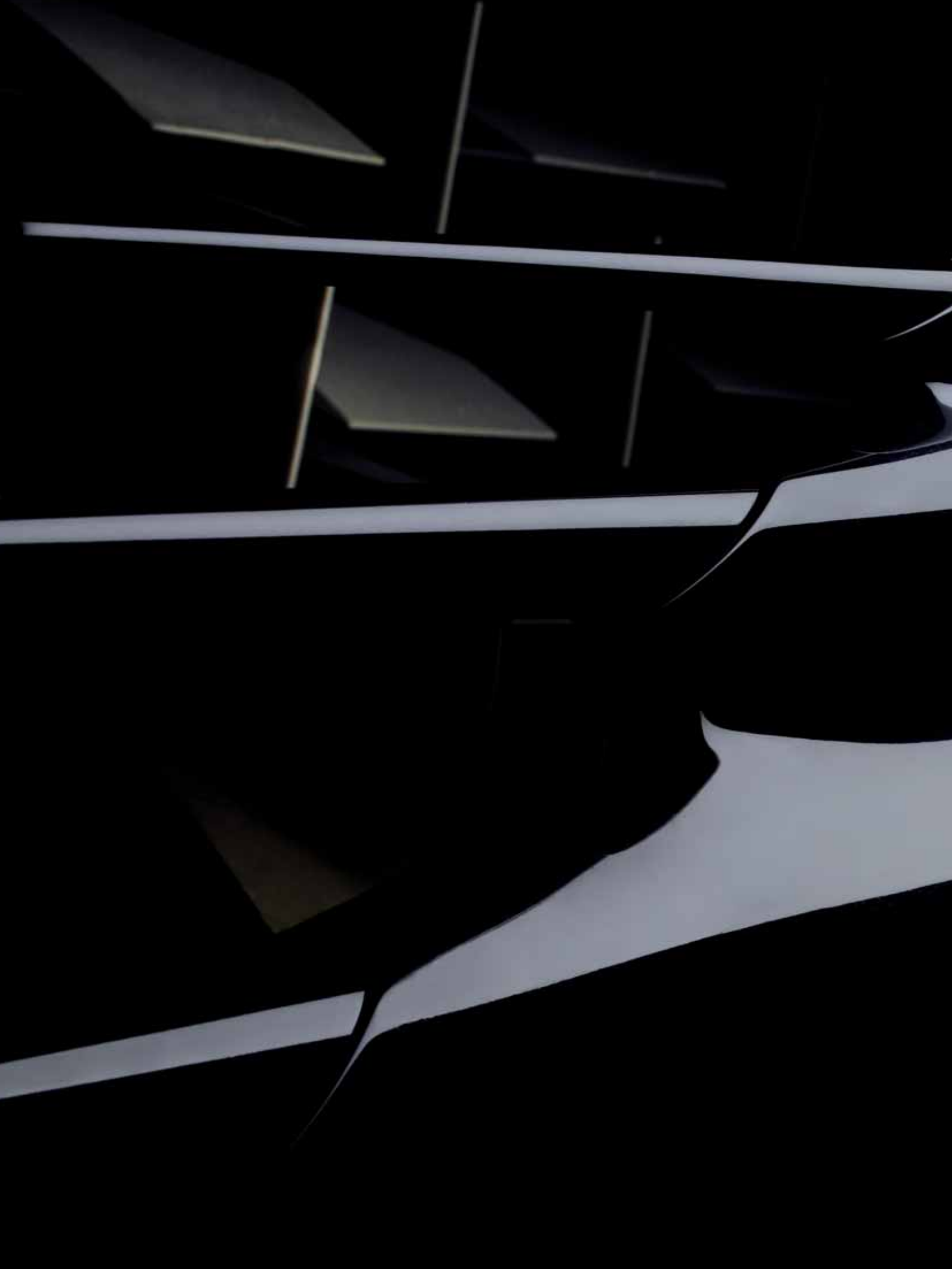
Each newly assembled speaker is tested in heavily insulated anechoic chambers. We check every element of the sound emanating from the front of the speaker. Unlike every other speaker manufacturer, we also check for any hint of unwanted sounds leaking from the back. Once that test is finished, we test the speaker yet again: this time in a range of domestic environments and listening rooms.

Only when all of these tests are completed and passed to our satisfaction do we give the Nautilus our final seal of approval: the B&W quality certificate. Included with every purchased Nautilus, the certificate names everyone involved in making and testing the speaker.

It also comes with documents showing the full results of every test we put the speaker through. Because it's not quite enough for us to be satisfied that your speaker works precisely as it should. We want you to be satisfied too.



Testing the limits: a display shows the frequency response of a Nautilus drive unit. Nautilus tweeter domes rims are reinforced with carbon fibre, which raises the first break-up threshold by 30 per cent, pushing it up to twice the limit of human hearing.





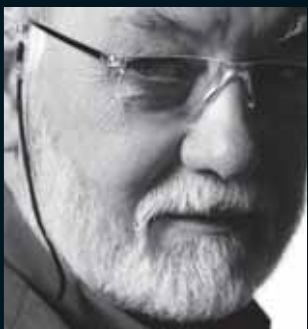
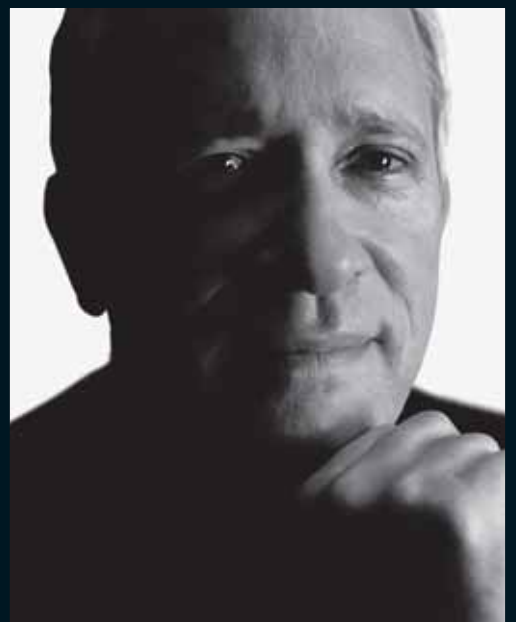
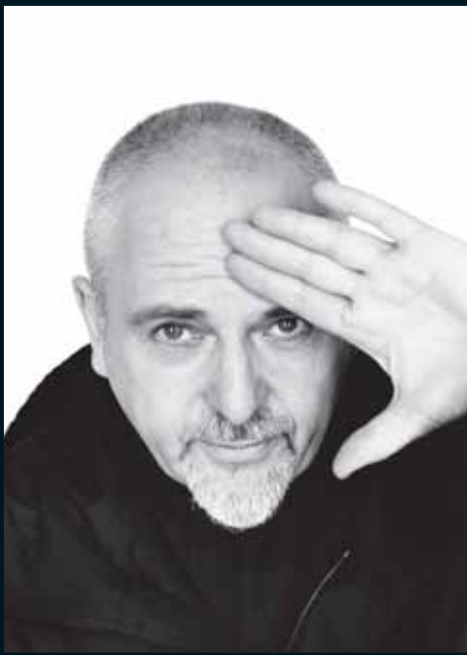
A lasting legacy

The Nautilus is much more than a high-end speaker. In its audacious design, in the quality of its components and manufacture, and in the pioneering spirit in which it was first conceived, it expresses and encapsulates everything B&W stands for. Put simply, it *is* B&W.

Many of the innovations and ideas we developed during the making of the Nautilus, from tapering tubes to drive unit design, can now be found not just in every B&W speaker, but in high-end speakers all over the world. But the Nautilus did it first. And, many argue, it did it best.

From the moment it was made, the Nautilus irrevocably changed and broadened our sense of what a speaker can be. It set a new standard by which other speakers must be measured. And it will continue to do so, now and in the future.





The Society of Sound

For B&W, the pursuit of true sound is about more than science and craft. It's a passion. Thankfully, we're not alone. Over the course of our 40-year history we've met many people – sound engineers, film score composers, product designers and all-round musical geniuses – who are just as driven as we are. We thought it was about time we brought them together.

The Society of Sound is an online meeting place for people who love sound. It's where to come for ideas and inspiration from those working at the cutting edge of music and sound design, and to find out more about people who are pushing the potential of sound to its limits.

If you're as passionate about sound as we are, you're very welcome to join us.

Find out more at www.bowers-wilkins.com/sos

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