The Audio Beat

Wilson Benesch Cardinal Loudspeakers

An exercise in invisibility through mechanical elegance

by Roy Gregory, April 30, 2013

"This is not the age of the pamphleteers. It is the age of the engineers. The spark-gap is mightier than the pen."
Lancelot Hogben – Science For The Citizen

"It has been said that an engineer is a man who can do for ten shillings what any fool can do for a pound."
Neville Shute – Slide Rule

In case anybody missed it, hi-fi geography is on the move. The Old World, the cozy set of relationships and established order of things, is shifting. Not so long ago you could divide the industry into manufacturers, distributors and dealers, each with a neatly defined and clearly understood role -- and woe betide anybody who stepped outside his or her allotted place in the great scheme of things. But the Internet and economic meltdown (not to mention the minor inconvenience of the globalization of retail markets) has bent things well and truly out of shape. The once carefully respected gap that existed between dealers and distributors has all but disappeared; the number of dealers who now also import products has mushroomed, while distributors have responded by increasingly offering their products directly to the end user.

Meanwhile, the internal differentiation between the various elements that constitute "manufacturers" has become significantly more apparent -- and arguably more important. Offshore manufacturing, increasingly complex technologies and the subsequent increase in specialization have meant that the increase in subcontracting has widened the gulf between those who genuinely manufacture and those who, in reality, simply assemble. And nowhere is that development more obvious than in the realm of high-end loudspeakers. After all, it doesn't take a lot of upfront investment or expertise to buy a few drivers off the shelf, knock together a wooden box and run a bit of software to lace it all together. Throw in the possibility of some fancy CNCed MDF cabinetwork and a lacquer finish, courtesy of any number of large-scale Far Eastern woodshops, and suddenly anybody can be a speaker producer. It is a reality that has left established loudspeaker manufacturers that still rely on wooden cabinets and OEM drivers scrabbling for credibility in a panicky dash to distance themselves from

the tsunami of imitators and pretenders bearing down on them. It's a barbarian horde that includes more than a few names that not so long ago stood shoulder to shoulder with those selfsame, august members of the audio aristocracy.

It's a brave new world and a whole new reality, where reputations are suddenly diminished in importance, and it's not what you do or where you do it but how you do it that matters. There's a new set of value judgments to be made and almost overnight (at least in audio evolutionary terms) there's a chasm opened between those who build in-house and those who simply buy-in. Now, it's not simply a question of whether you build parts or cabinets yourself, but how much of the finished speaker you actually produce and how much is built by third parties and shipped in. Of course, subcontracting isn't in itself a bad thing, and the whole equation is further complicated by questions of oversight, quality control and parts cost. It's entirely possible that you can get a result that's both better and cheaper by buying core elements from a third party.

But one argument in favor of in-house production remains almost unassailable. We refer to "loudspeaker systems" for a reason; they consist of a cabinet, drivers and (generally) a crossover. For optimum performance those elements must all be engineered in concert to create a single, balanced whole. Each adjustment or accommodation, each acceptance of what is available, as opposed to what you really want, diminishes that whole. It means that if, for instance, you rely on OEM drivers, your relationship with the supplier must attain the level of virtual partnership to offer any chance of serious success. It's one advantage that the established high-end manufacturers still enjoy, but even that is coming under threat, as the traditional driver suppliers feel the pinch. Now, seemingly anybody can order the "special," assembled from a menu of existing parts (which is just a recipe for broader compromise) while prices are spiraling ever upwards.

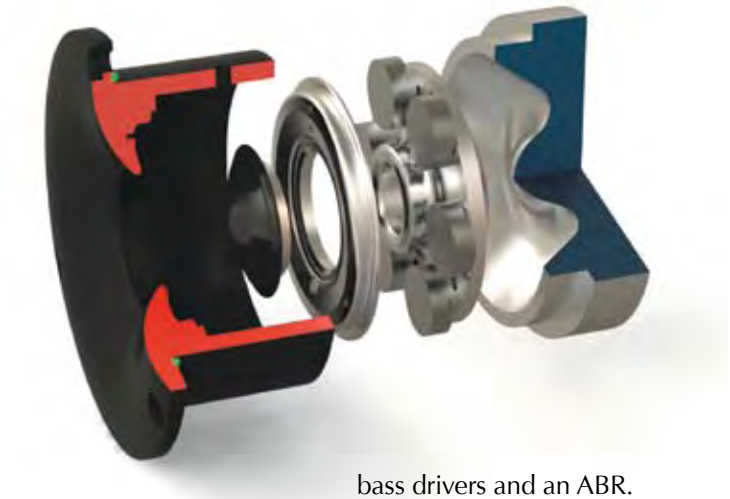
Set against this backdrop, it should come as no surprise that those loudspeaker companies that seem to be flourishing are the ones that put more and more in-house effort into their designs. In a market where recent prices seem to defy gravity and many manufacturers use minor reengineering of existing systems to justify major price hikes, it should come as no surprise that it is a product like the KEF Blade, a speaker that is not only entirely in-house engineered and built, but manages to creatively combine UK and Chinese manufacturing, that has set a new price and performance benchmark -- ruffling more than a few establishment feathers along the way.

Which rather raises the question, Where does that leave the dedicated high-end manufacturer? One answer might well be Sheffield, a steel town with a dour reputation, located deep in the heart of the UK's industrial midlands and immortalized in the title of that great Joe Cocker album. Since the dark days when the British steel and coal industries collapsed, Sheffield has reinvented itself as a center of high-tech manufacturing, with composites, advanced materials and manufacturing processes all well to the fore. Look about and you'll see everything from aerospace and Formula 1 to extreme sports represented -- as well as Wilson Benesch, purveyors of no-nonsense engineering solutions dedicated to the pursuit of audio excellence. This is the story of their latest and most ambitious loudspeaker to date. It is also a story of dedication to sound engineering principles and innovative materials and manufacturing techniques. How much of this loudspeaker is built in-house? Pretty much every last little bit.

Engineering solutions

Let's start with the drive units used in the Cardinal. At first glance, you could be forgiven for assuming that this speaker only uses two different drivers, the in-house tweeter and a 7" cone unit, but appearances are deceptive. One look at the carefully machined driver basket and beautifully turned motor housings on the 7" units, all calculated to minimize rear reflections and maximize airflow, should tell you that these are no ordinary, off-the-shelf drivers. In fact, every metal element that goes into them, apart from the voice coil wire and the incredibly

powerful rare earth magnets, is produced in the Wilson Benesch machine shop. Less obvious is the fact that the cones are also produced in-house from what is (in hi-fi terms) a unique material: isotactic polypropylene. This is a thread that can be woven into various patterns or shapes and then subjected to pressure and temperature. Under the right conditions the surface of the fibers melts and then re-solidifies into a single composite whole. The nature of the polypropylene itself, along with the versatility afforded by the woven construction, allows the creation of incredibly stiff, consistent yet self-damped cones whose mechanical behavior can be precisely tuned. The absence of a resin bonding the fibers removes both extra weight (a good thing, as polypropylene isn't the lightest material) and the potential for sample-to-sample variability. Look closely at the Cardinal and you'll see that there are actually three different cones on show. Starting from the top of the baffle, these cover the lower midrange, the midrange, and the bass, covered by two



bass drivers and an ABR. But that's not the whole story, as there are actually three more drivers hidden from view inside the cabinet -- but before we get to that, let's take a look at the tweeter.

The Semi-Sphere is Wilson Benesch's new flagship high-frequency unit, and once again, at first glance, it might seem like a peculiar choice. Given the inclusion of the Murata super-tweeter in the company's Trinity and ACT C60 designs, a factor that clearly indicates an appreciation of wide bandwidth, the use of a silk dome might seem like a step backwards. But look beyond the faceplate and again appearances are deceptive. The silk dome is supported from behind by a tiny, precision-engineered carbon-fiber brace, while the rear chamber, behind the motor, is carefully sculpted to minimize reflections and resonance within the enclosed air-mass. Add in the optimally contoured front plate and you have a unit that delivers the proven benefits of the soft-dome approach (excellent tonal and dynamic shading and contrast) with superior dispersion and extension, features that together deliver an impressive claimed high-frequency roll-off of -3dB at 35kHz. Okay, that might not be in diamond-dome territory, but it comes in combination with the proven performance benefits of silk-dome technology, with its enviable reputation for accurate tonal reproduction, a natural energy envelope for notes and a lack of glare. It is also well suited to low-order crossover implementation and that, as we shall see, is key.

So when you look at the crowded front baffle of the Cardinal, what you are actually seeing are five different drivers, all produced in-house. It represents a level of engineering and investment that is only possible because of the use of innovative materials like the isotactic polypropylene, both a versatile and elegant solution to the problem of precisely tailoring the mechanical response and acoustic properties of all those different drivers. Add in what amounts to a modular system of baskets, magnet assemblies and motor parts and Wilson Benesch are able to create dedicated midrange, lower-mid, bass and ABR drivers, all precisely tailored to the final system, without upfront parts costs killing the project. But the implications run deeper than that. The configurable nature of the driver technology doesn't just enable the design of the speaker system, it's a fundamental consideration within it, a fact that becomes only too apparent once you take a look at the crossover topology -- or rather, lack of it.

One place where less is definitely more

A firm believer that crossovers really are the root of all evil, Wilson Benesch director of engineering and chief designer Craig Milnes has opted to take the unusual step of running both the midrange and lower-midrange units wide open, with no subtractive crossover elements at all. He has also disposed them symmetrically around the tweeter, with the lower mid in the upper position, in what amounts to a pseudo d'Appolito arrangement, although the midrange drivers are obviously carrying different frequency ranges. The Semi-Sphere

tweeter is rolled in using a simple first-order crossover to minimize phase and timing errors. Together, this three-driver array constitutes a unique arrangement (at least as far as I'm aware) that Wilson Benesch refer to as the Troika Concept. Below the midrange array, the bass leg is another first-order slope, again maintaining system coherence and phase integrity, and minimizing subtractive and electrical losses.

This light-touch approach to driver integration offers considerable musical benefits, but it does place a heavy emphasis on the mechanical behavior of the drivers themselves, especially their out-of-bandwidth break-up modes. It's an unusual choice for a multi-driver, ultra-high-tech system like this one, one more usually found in minimalist, high-efficiency speakers, but it makes perfect sense of the Cardinal's technological strengths -- and weaknesses. If you are using a higher-order filter with steep slopes and rapid driver roll-off, then you can concentrate on a narrower pass band, but the Cardinal's crossover uses either shallow slopes or an entirely acoustical/mechanical roll-off in the case of the midband drivers. What makes this possible is the ability to tailor the drivers' mechanical responses so precisely, while the lack of subtractive filter elements between the amp and the drive unit delivers enhanced control to overcome the heavier mass of the polypropylene cones compared to, for example, ceramics. The result is a highly unusual crossover that is best described as two-way first-order electrical, but four-way acoustical design.

As well as maintaining as much of the drive units' inherent efficiency as possible, the benign slopes of the Cardinal crossover present the driving amplifier with modest electrical demands -- a 6-ohm nominal impedance with a 3-ohm minimum -- and reduced reactive load. That lack of sharp corners in the impedance plot and the back EMF that would go with them means that the driving amplifier gets a relatively easy ride, an important compensation for the moderate overall system sensitivity of 90dB and a crucial factor if the Cardinal is to deliver convincing dynamic range and musical authority.

Completing the jigsaw

The Cardinal cabinet is also far more complex than its sleek external appearance suggests, both in its construction and internal arrangements. It is based on a series of aluminum extrusions and carbon-fiber-sandwich structural elements that are, like the metalwork for the drivers, modular in nature. The massive extruded-aluminum baffle is carefully shaped to reduce diffraction, but also minimize resonance

That's engineering

Wilson Benesch was established in 1989, its first product a belt-drive, sprung turntable employing a carbon-fiber subchassis. Next up was a tonearm, the ACT One, another design using innovative materials and engineering. A variation on the unipivot principle, the 'arm employed a three-point kinematic bearing (one ball resting against three others) to prevent bearing chatter or wander. It's an arrangement that can be seen embodied in the feet fitted to the Cardinal. There was a clever underhung counterweight, but the star of the show was the massively tapered one-piece carbon-fiber armtube incorporating both the headshell and a stubby but entirely practical finger lift. It looked impressive, it looked different and it sounded impressive too.
But most impressive of all is that the basic design is still in production. Now morphed into three different but externally similar models that share those same essential ingredients. The flagship employs nanotube technology to further improve the stiffness and drop the weight of the armtube, while the ACT Two is an

improved version of the original, using superior carbon for its armtube. But the model that impresses me is the entry point, the ACT 0.5. Essentially this is mechanically and materially identical to the original 'arm, with the same utter simplicity and innovative materials and engineering. Fit and finish are flawless, and the performance is remarkable for the price. Oh yes, the price? That would be £1035 -- around $1500. As I said, that's engineering.

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and bending modes. Variable thickness and curved "returns" that extend a full 50mm back from the baffle face make for an incredibly rigid element. Although the raw extrusion itself is supplied to Wilson Benesch in 5-meter (16') lengths, all machining and finishing is done in-house. Behind this, the rear half of the cabinet is formed from a curved W-section, formed with combined carbon-fiber and fiberglass skins, sandwiching a thick structural foam core. The result is again incredibly stiff, but it is also extremely light, while the foam core material and mixed-material skins make for excellent self-damping. This carbon composite channel is the result of a closely guarded, proprietary production process, the materials, expertise and plant required making it an incredibly costly element -- a fact that Wilson Benesch offset by using it across their range of products. Of course, one channel section can't do it all, given that different systems demand different cabinet volumes, but that's where clever modular construction comes in. The composite channel is linked to the baffle by extruded "cheeks." By varying the depth of these, the volume can be dialed in for different systems, while, again, the extruded profile allows extreme shaping of the elements to increase stiffness and resist resonance. These side panels on the Cardinal are fully 180mm (7") in depth.

Finally, the back of the cabinet is finished with a beautifully sculpted and extruded-aluminum post that adds another clamping element as well as significant additional stiffness. The end result is an enclosure that involves clamped mixed materials in a self-damping sandwich structure, virtually devoid of parallel internal walls, with all the benefits of an ultra-stiff material like aluminum, but with none of the ringing that normally goes with it. Throw in the low energy-storage characteristics of the composite-channel section and this could be a theoretically near-perfect cabinet.

The internal volume itself is constructed from two separate elements. The large upper enclosure houses the tweeter and lower-midrange unit. The lower cabinet contains the midrange driver in its own separate enclosure, loaded by an electromechanically damped ABR that vents through the slot between the two sections of the cabinet. That driver disposition might, at first glance, appear quite literally to be upside down, but like so many elements of the Cardinal package, there's an underlying logic at work. By placing the lower-mid driver in the upper cabinet, along with the high-frequency unit, Milnes manages to reduce mechanical intermodulation distortion between the two units, the lower-mid's output simply not overlapping with the tweeter's range. It also allows him to optimize the lower-mid's loading chamber, in terms of size and shape, without eroding the internal volume available for the low-frequency enclosure or compromising the spacing of the drive units on the front baffle. One physical constraint in the construction of the Cardinal is the length of the composite channel used in the cabinet. This can only be produced in lengths of up to 1 meter, so by placing the upper-midrange driver, with its smaller air chamber, in the lower cabinet, Milnes maximizes the volume of his low-frequency chamber without increasing the footprint of the cabinet. He also extends the same elimination of intermodulation effects seen in the upper cabinet across the speaker's entire range.

Despite the Cardinal being a four-way design, no driver shares its baffle with another driver producing an adjacent frequency range. This is particularly crucial when it comes to the critical lower-midrange driver, where energy transmitted via the cabinet from the bass units would have a seriously detrimental impact on musical pace and dynamic authority, something that is all too apparent in those speakers that try to sound bigger than they really are.

Once you get inside the lower cabinet, things get even more complex. The midrange chamber is loaded by an electromechanically damped ABR, a more controllable implementation of open-baffle design. This ABR vents upwards into the slot between the upper and lower cabinets. The remainder of the lower enclosure contains the bass system. What at first looks like three 7" drivers is actually a pair of isobarically loaded drivers, in turn loaded by another front-mounted ABR.

The Isobaric arrangement demands a second pair of drivers, placed immediately behind the units mounted on the front baffle. These are positioned as closely as possible on their own massive aluminum sub-baffle, a part that weighs in at 35 pounds before you mount the drive units. It is this substantial element that underpins the speaker's bottom-end authority and clarity, preventing any motion in the physical reference seen by the bass drivers. Anybody worried by the apparent lack of cone area for a speaker of this price should be reassured by the paper extension to a -3dB point of 25Hz.

The top of the cabinet looks like it would be more at home in the Olympic velodrome than gracing the uppermost point of a loudspeaker. Whilst it has an undeniably powerful visual impact, again the purpose is to eliminate resonance and any parallel surfaces inside the lower-mid chamber.

The Cardinal stands on the most substantial base I've yet come across, machined in-house from a single slab of 50mm (2") aluminum. If the purpose of the massive baffle and the stiffness of the cabinet as a whole is to offer a stable mechanical reference for the drivers, this is the part that delivers the necessary mechanical ground. It stands on three thick stainless-steel posts, one fixed at the front while the two in the rear corners, each having a massive but beautifully executed top-mounted adjusting wheel. These might look like overkill, but let me reassure you that when a speaker weighs 180kg (that's the best part of 400 pounds!) and the posts responsible for leveling it have threads 25mm (a full inch) in diameter, those large-diameter wheels are not just a bonus -- they are essential to achieving accurate vertical and rake angles. Each of the threaded posts is tipped with a large tungsten-carbide ball. This interfaces with three identical balls captured in the large disc feet provided with the speaker, an arrangement -- first seen in the Wilson Benesch tonearm -- that guarantees minimal point contact. All these parts, like the driver baskets and motor assemblies, even the four sets of terminals mounted on the speaker's underside, are produced in Wilson Benesch's own CNC shop.

Standing in front of the Cardinal and describing it as conceptually minimalist or pared-down might seem strange. The base is over two feet in each dimension, while the tall, narrow (8" wide) cabinet rises 69" from the floor and is 22" deep. A quick head count should reveal that, contrary to first impressions, what you are actually looking at is a four-box speaker system with no fewer than eight separate internal acoustic volumes and a grand total of 18 bespoke drive units. The cabinet is entirely constructed from aluminum or engineering composites, with not one piece of wood in sight. In fact, that 180kg weight should act as a sobering indicator as to just how much aluminum there is in the Cardinal -- especially when you consider that around half the cabinet volume is provided by the lightweight composite sandwich section. The upshot is a speaker that is neither particularly easy to install nor drive -- but is well worth the effort.

By now, you should begin to appreciate that this is a "speaker system" in the fullest sense. Virtually every single element has been purpose-built, honed and refined in-house to create an interlocking jigsaw of parts that becomes the whole. The modular cabinet, indeed the whole notion of a wide-bandwidth system based on 7" cones, wouldn't work without the configurable drivers; the use of extruded sections and the sandwich cabinet are only possible because the costs are defrayed across the range; the system only works because the engineering incorporated is repeatable and manageable -- and that's only because the entire process is carried out in-house. These are mutually dependent conditions, a set of circumstances that can only exist in concert. Remove any one and the whole thing collapses like a house of cards -- which helps explain why, in an industry awash with me-too product and more bandwagons than the Calgary Stampede, the Cardinal is physically, materially

and topologically unique. In an industry that seems to venerate over-engineering, this is the opposite; this is a true system solution, with appropriate engineering applied to each and every aspect. The mantra might be, "enough and no more," because in a loudspeaker, each and every additional, unnecessary element comes with its own additive cost, its own sonic signature. It might seem ridiculous to describe any speaker costing nearly £55,000 as a bargain, but in pure engineering and technology terms, that's exactly what the Cardinal represents.

Any large multi-driver speaker inevitably adds complexity to the equation. The challenge is to ensure that the benefits from the increased size, cost and complication outweigh the drawbacks. It's an acid test the Cardinal bypasses with flying colors, sidestepping the issue neatly through a combination of conceptual elegance and engineering excellence. In fact, one of the greatest complements I can pay the Cardinal is to say that it doesn't sound like a big loudspeaker. But that is only half the story. In fact it doesn't sound much like a speaker at all.

System setup

Despite its substantial weight, the Cardinal is surprisingly easy to manhandle, simply because it offers a plethora of secure handholds. Unlike with many high-end speakers, you can actually get ahold of it! Unfortunately, that's the easy bit.

The ball-bearing interfaces on the feet (together with the substantial weight) made it surprisingly difficult to slide the speaker, even on my wooden floor, making small positional changes extremely difficult. I eventually resorted to some felt-based footers for placement purposes, before installing the dedicated feet. The other practical difficulty concerns connecting the speaker cables. Wilson Benesch have created their own combination terminals/binding posts. These use a short post (for bananas) and a large-diameter nut for spades. The design is simple, low-mass and secure -- all commendable virtues. However, the fact that the Cardinal crossover offers separate inputs for each leg, each positioned beneath the speaker and only identified by engravings on the black anodized undersurface of the base, presents a challenge. That's eight almost inaccessible terminals that you don't just need to connect, you also need to identify for polarity and purpose. Given that most people won't be quad-wiring the speakers, you'll also be using jumpers, meaning that you'll be making multiple connections to several of those terminals. It's a scenario where a little bit of planning and the right tools go a long, long way.

The first thing to ensure is that your cable configuration is correct. That means having enough jumpers that match your speaker cables (you really don't want to spoil this ship for a happeth of tar!) to wire all four sets of terminals. If you use single wires, that means three sets of jumpers; if you use biwires, two sets. Next -- install the jumpers while the speakers are horizontal, and ideally make sure that you visually identify the polarity and orientation of the terminals. A strip of red tape, positioned to one side and with a bottom-to-top arrow at one end will do nicely (and can always be removed after installation is complete). Finally, once the speaker is upright and roughly in position, one person should tilt it while you connect the speaker cables to the correct terminals. This will be considerably easier if you have a small flashlight on hand and the cables are terminated with clearly color-coded bananas. The last thing you want to be doing is wondering whether that's a positive or negative connector while your hands are underneath

a 400-pound loudspeaker. If your cables use spades, this whole process is considerably more awkward, although ensuring that you have a 13mm ratchet socket wrench (that's a shade over 1/2") will at least make it possible. In one of those ill-advised fits of enthusiasm that often accompanies the arrival of new products, I attempted to swap the cables on the Cardinal from the original setup to a biamped, bi-jumpered, all-spade configuration using a standard spanner. The air was well past blue and somewhere close to a deep, deep purple before I bit the bullet and finally dug out the socket set. Rest secure in the knowledge that I suffer so that you don't have to -- and learn the lessons of my stubborn stupidity!

The other key aspects of Cardinal configuration are to do with positioning and angles. With any wide-bandwidth loudspeaker, placement is critical, and this one is no exception. But equally important is ensuring that the speakers are deployed perfectly symmetrically, in terms of attitude and toe-in. I found that they performed best pointing at the outer edges of a seated listener's shoulders, with distance and symmetry established using a laser level. Also critical is getting the cabinets absolutely vertical in the lateral plane, and to ensure that they have identical rake angles. My lowish seating position meant tilting the speakers very slightly forward for optimum midband linearity and presence, which is where those massive adjustment wheels and the speakers' stable footprint really come into their own.

I drove the Cardinals with a range of different amps, including the VTL MB-450 IIIs, the Berning Quadrature Z monoblocks and the fascinating Avantgarde XA combination. All of these amps, ranging between 150 and over 400 watts in terms of rated output, were perfectly happy driving the Cardinals, but there was no mistaking the character of each. That's a double-edged sword; if you love your amps and the system is really well sorted, then you'll just get even more of what you already like. But the speakers' lack of coloration or subtractive tendencies certainly lay bare the quality of the driving system, so make sure you understand just what they're telling you. Where complex crossovers and intrusive cabinets cover a multitude of sins, the Cardinals deliver their message with a forthright honesty that can be a bit on the bracing side if there are problems you weren't aware of lurking upstream.

Just as differences between amps were unusually stark, so too were differences between cables; the contrasting attractions of the Nordost Odin and Crystal Cable Absolute Dream have rarely been so obvious. What was even more obvious was any discontinuity within the cable loom -- hence my earlier note regarding matching jumpers. But get everything just so and the Wilson Benesch speakers really let you hear the benefits. Whilst each of the amp and cable options listed above held their own appeal and particular fascination, it was biamping the speakers with the Siltech SAGA amplification system that was to prove spectacularly successful. Naturally, that reflects the quality of these exceptional electronics, but the speakers have to be able to respond, and the Cardinals did -- with gusto!

It's not what you see

We'd like to think that we all pretty much know what music sounds like, but here's a question: do you know what your loudspeakers sound like? If the answer is, "They sound like music," then the chances are that more often than not you've acclimated to the point where reproduction and reality have blended to such a degree that what you hear is governed as much by expectation as fact. Listening to the sound of live, acoustic music (as opposed to listening to the music itself) is a sobering experience. How an orchestra or group presents, the effect of the space in and around the musicians, the clarity and independence of each individual musical line and the physical energy high- and low-level that they produce: you quickly realize just how flawed many audio systems are and, ironically, how often those that excel sonically also fail musically -- and spectacularly so.

Now, let's play a little game of spot the speaker. Imagine if you will that you are sitting in front of an acoustically transparent curtain, behind which is a pair of speakers playing a familiar recording. Do you think you could identify the type of speaker playing? Not whether it is a KEF or a B&W, a Wilson or an Avalon. No, I'm interested in far broader groupings than that. Is it a dipole electrostatic, a dynamic system, a horn or a minimonitor? That's right -- as simple as, Is it big or small? Is it built into a box or not? The answer should be yes, you can identify speakers by broad type -- most of the time. Not always and you will get fooled occasionally, partly because in many cases the speaker designer is trying to do exactly that: making his little box sound bigger than it is, or vice versa. But the point is that each of these broad design approaches brings with it its own set of strengths and weaknesses, its thumbprint that it imposes, more or less, clearly on each signal that passes through it. We talk about hearing the box, the crossover, tweeter breakup or comb-filtered low frequencies, each in turn narrowing the possible type or identity of the mystery device.

Except that in this instance, the speaker behind the curtain doesn't conform to expectation, doesn't represent an identifiable thumbprint -- it's not in CODIS, the NFR, the NPPD or any of your other available databanks. Instead, what you hear, what you experience, is a bundle of apparent contradictions. Absolutely seamless top-to-bottom integration suggests a single-driver design -- like an electrostatic -- a notion backed up by the lack of any thickness or obvious boxy coloration. In fact, the even dynamic and harmonic spectrum is almost spookily consistent. Has to be a single driver! But it's consistent right down to the bottom of its range, and that range runs deep. Nor does it have the exaggerated, spacious soundstage that so many find attractive in dipole designs.

So if it's not a dipole and it is wide bandwidth, if it is an electrostatic, it's either a very clever or a very strange one. But there are other telltales we can look for: the crisp, etched leading edge and snappy dynamics of ceramic (and other ultra-stiff) cones? Nope -- nowhere to be heard. There is no dome-tweeter fizz and edge that come from early breakup modes, nor is there the almost muted-energy effect of the small-diameter diamond domes, so clean and devoid are they of added distortion or ringing. Likewise, there's none of the thump of a really big driver in an even bigger box, none of the hyped midbass dynamics that many larger speakers use to justify their size (and price). It's obviously not a horn -- it doesn't have the sheer immediacy -- but it doesn't have the integration, coloration or bandwidth limitations either. Nor does the bass sound constipated or extruded, which it would if this were a little speaker sounding bigger than it is. Maybe it's a closed-box electrostatic hybrid with a really big and seriously well-integrated subwoofer. However, not only am I unaware of any such system (except the Wisdoms), the bass, while it does run deep, doesn't go as deep as any designer would run it if that was the approach. At this point I'd be beyond clutching at straws and ready to admit defeat.

The speaker behind the curtain is of course the Cardinal. Why the fan dance? To make you realize two things about this speaker: what you see is not what you hear, and what you hear is both unusual and very special -- but because this speaker doesn't play the game by the same rules of so many existing high-end designs, its virtues are easy to miss. Where the bigger, flashier and noisier competition shouts, "Look at me! Look at what I can do!", the Cardinal is all about what it doesn't do. Speakers with 15" woofers whack you in the chest with bass beats -- because that's what you expect. Electrostatics sound spacious and ethereal -- because that's what you expect. Minimonitors give pinpoint placement and separation -- because that's what you expect. Too many designers make a virtue of the speaker's strengths rather than trying to ameliorate its weaknesses, because it's easier to sell the spectacular virtue that stands out from the crowd than it is to market self-effacing honesty. The Cardinal sounds understated and unexaggerated. It certainly doesn't sound like most listeners would expect a £55,000 speaker (roughly $80,000) to sound. In fact, as I said earlier, it doesn't sound much at all.

What *does* the Cardinal sound like? Let's ask a different question: what does music sound like through the Cardinal?

Thinking big

Plenty of people faced with a small speaker reach straight for the biggest, most demanding recording they have to hand. Me, I'm the exact opposite. Show me a big speaker and the first thing I want to do is play something really small and delicate. Why? Well, all those drivers, that great big box; playing big and loud is what it's been designed to do. I want to

know what happens when all that hardware becomes an embarrassment -- a bit like taking a Ferrari to the supermarket. If it's your only car, it sure as shootin' needs to handle the shopping. You don't get much more delicate, fluid or demanding of system articulation than Julia Fischer's Bach sonatas and partitas [PentaTone SACD 5186 072], an object lesson in sinuous musical precision. Play them on the Cardinals and it's an instructive experience.

Firstly, the speakers establish a remarkably clear and totally independent acoustic space. There is no sense that those forbidding black towers full of drive units a re the source of the sound -- or that they have anything at all to do with what you are hearing. The acoustic simply exists, created in front of you, and within it is the remarkably stable, solid image of Fischer's violin, not as a separate entity but intimately connected to its environment, the instrument and the air around it. We call it an "acoustic" for a reason. There's none of the etched over-separation or hyper definition that passes for high-end sound. What there is is a musical event, with player, place and the relationship between them preserved intact.

Secondly, it stays that way. With a lot of speakers you can use the volume control like a zoom lens; turn it up and that central image will get bigger or closer -- and often both! When I describe the soundstage established by the Cardinals as stable, what I mean by that is that it stays the same size and in the same place, irrespective of volume. Turn it up and the music just gets louder. Even more impressively, turn it down and it just gets quieter -- no collapsing dimensionality, no loss of dynamic range. With a lot of speakers, especially those with a lot of drivers or a complex crossover, there's a threshold for every recording, below which it doesn't really come alive. If the Cardinals have such a threshold it's subtle enough that I haven't noticed it -- and it's something that normally I pick up on in a flash.

Thirdly, despite the fact that we are discussing solo violin here, the dexterity, rhythmic fluidity and sheer range of tonal and dynamic shadings required to really do Fischer's performance justice are way beyond the capabilities of most audio systems, and speakers in particular. The sheer intensity of the live experience is quickly eroded by the gating imposed by so many audio setups. Their inability to track the expressive fluidity in the playing is starkly apparent as lines collapse and bowing becomes clumsy. Yet these are system impacts; they are not there in the performance. The Cardinals deliver a sense of musical concentration and focus on the event that is quite uncanny. The control and precision, the position and juxtaposition of the notes that Fischer plays is so unencumbered, so precise that you are left in no doubt as to both her musical and technical abilities. The contrast between phrases, the harmonic palette of the different strings -- these things are starkly, beautifully apparent. It's not that she sounds like a better player (with a better fiddle). Instead, you can really hear just how good she is, just how good her instrument is and that it's a Guadagnini, more subtle and harmonically complex but less powerful than a Strad. This is all about the music and the speakers as window onto that music -- and that's just how it should be.

Thinking small

That's seriously impressive performance for any speaker. It's doubly impressive given the number of different drivers involved here. But that is exactly the point. The Cardinal looks like a big, super-complex system, yet electrically speaking and in many ways mechanically speaking too, it's far less complex than most speakers out there. Think back to my description of the unusual crossover topology employed. Despite the nine-drivers-per-cabinet component count, the Cardinal uses a first-order, shallow-slope, two-way electrical crossover -- about as simple and (in time and phase terms) as unobtrusive as it gets. Yet this is a four-way speaker, those other three-driver transitions being handled mechanically, by tailoring the acoustic output of the mid and lower-mid drivers.

Yet, what my description of Ms. Fischer's performance should tell you is that this is arguably one of the best-integrated multiway speaker systems I've ever heard. Or, in other words, Wilson Benesch have achieved mechanically better and certainly far less musically intrusive results than you can get from an electrical/subtractive approach. Whilst we've always understood the benefits of running drivers wide open -- especially when it comes to preserving musical nuance and expression, it was never taken really seriously in the high end because of perceived issues with poor control and absolute accuracy. Now, what EgglestonWorks and Reference 3A have been doing for years, Wilson

Benesch have both extended and improved, with not just one midrange driver running wide open but two, broadening the range and refining the approach to a point where it's not just a viable alternative to electrical/subtractive crossovers, it's superior to all but the very best of them. The Cardinal might look like a big, butch high-tech monster, but inside beats the heart and sensibilities of an ultra-purist little two-way. But don't be fooled. Even a small speaker can hide a very big club behind its back!

Another way in which the Cardinal has more in common with small speakers than large is the way it sounds at low frequencies. When I said that too many large-driver designs feel the need to remind you that yes, that really is an 11", 12", 15" or whatever-sized bass unit it might be, I should point out that whilst that voicing is in part down to the designer, it also reflects the nature of the drivers themselves. There really is a difference between bass from one big driver and bass from a lot of little ones. One reason for that is simply how much air a big driver moves, with its massive cone area and long throw. The other reason is that the big, heavy cone is hard to accelerate or control, demanding a stiff suspension to keep things heading in the right direction -- all of which adds up to a speed of response that simply can't match smaller drivers (although there will be rather more to say on that score later). So, are you therefore much better off with a load of small drivers? Not necessarily. Firstly, you have to get them all heading in the same way at exactly the same time (which isn't as easy as it sounds) and then you have to have enough of them to move sufficient air. Of course, the more drivers you have, the harder it is to keep them all in synch.

For Wilson Benesch, the small-driver approach was always going to be the preferred path, imposed by the constraints of their cabinet construction. The challenge was to overcome the limitations. The isobaric solution adopted might be expensive, adding little or no perceived value to the finished article, but it works -- it really, really works, especially in the context of this speaker. Not only does the arrangement overcome the inherent frequency restrictions normally imposed by smaller drivers, the close-coupled air cavity acts to average the response of the four units, units that are already pretty precisely matched, having been built for purpose entirely in-house. Add to that the fact that the physical and material similarities between the different drivers in the system, as well as their dispersion, brings a "cut from the same cloth" quality to their integration, and it should be no surprise that the Cardinal's bottom end is a seamlessly natural extension of that expressive and fluid midrange. This is bass that's about articulation, clarity and finesse. It is not about great, clumsy, clod-hopping drum beats flying out of the soundstage like cannonballs in a bad 3D movie.

Instead, the bass is tactile and mobile, with a sense of pace and shape, attack and decay that matches the midband for unobstructed ebb and flow. *This One's for Blanton* [Analogue Productions CAPJ015] provides an acid test for bass pitch and timing. With only two instruments at work, the relationship between them is crucial, and if the low frequencies are even slightly out in terms of weight, pace or placement, it's not just obvious, the music loses any sense of shape or interest. It was a test the Cardinal passed with flying colors, Ray Brown's agile fingering a captivating counterpoint to Ellington's percussive piano interjections. Instead of stark and disjointed as it can so often be, this was music with a deeply ingrained groove, played with an obvious affection

by two stellar performers. Likewise, "Little Triggers" from Elvis Costello's *This Year's Model* [Radar RAD 3 LP]. The shape and substance of each bass note, each bar is crucial to the undulating rhythm of the song, its sense and sensibility. It's no exaggeration to say that the entire edifice rests on that simple, repeated, rising and falling sequence, its steps and hesitations underpinning the angst and agony in the vocal. The drums are delivered with not just impact, but texture, volume and (dare I say it?) personality. There's no mistaking them for a drum machine, and again it adds to the humanity and emotional connection of both the song and the performance.

This is bass that's about integration and musical understanding. It's not about impressing your mates. So, separating bass and cello on orchestral recordings is simplicity itself, even with unfamiliar pieces, making the musical roadmap that much easier to read. Likewise bassoon, tuba, timps and double bass -- all have their own distinctive place and timbral identity. Orchestral tuttis don't homogenize into a single low-frequency grunt, but even more importantly, the sort of faint echoes in the distant deepest bass that underpin the sparse almost-silences so beloved by Shostakovich are full of texture and character, a pulse with shape and color, rather than just a dull thud. Whilst Petrenko's recording of the Fifth Symphony is possibly the finest example of this, if you want to hear orchestral layering at its very best, the third movement of his First Symphony performance [Naxos 8.572396] reveals not just his total mastery of the score, but the Cardinal's ability to deliver that performance intact and in your room. As alternatives you could take almost anything from the Berglund cycle on EMI, or the Gorecki Third Symphony on Polskie Radio [PR SACD2], with the composer conducting the Polish National Symphony Orchestra. Any one of these will clearly reveal the clarity and intelligibility that the Cardinal brings to the musical foundations, a clarity and lack of clutter that extends up through the entire range. Living with the Cardinal, you soon realize just how much most speakers add: a little here, a little there. You may not notice each little addition, but collectively they hold back the performance, the music and your enjoyment.

Playing really large-scale works reminds that the Cardinal is a large speaker rather than a full-range design. It doesn't match a Wilson Audio Alexandria XLF or Focal Grande Utopia when it comes to sheer scale or bottom-end wallop. There will be those who will bemoan a lack of obvious weight from a speaker of this size and price -- but that misses the point. Yes, you could have more weight, but it would cost you and be a bill paid in musical terms, with an interest rate that would make a payday-loan company blush. The Cardinal excels within its range, precisely because it doesn't attempt to push the boundaries of that range. As we'll see, what comes out depends more than normal on what you put in, but like the big-driver debate, I'll return to that later. But first. . . .

And smaller still

Yet another surprise element in the Cardinal's composition, at least as far as appearances go, is the inclusion of a silk-dome tweeter. With most of the competition boasting ribbons, diamonds or beryllium, even those with a fabric driver go for something a bit more modern than a simple dome -- the ring-radiators being the obvious example. But there it is, Wilson Benesch's Semi-Sphere tweeter, looking little different to the sort of driver that graces many a sub-$1000 design. Of course, as we know, there's a lot more to the driver than the way it looks, and arguably its external appearance is even more misleading than that of the other drivers here, but the proof of the pudding is in the listening, and when it comes to music, the Semi-Sphere delivers on all its promises.

Habituated as I am to RAAL and Raidho ribbons, various diamonds and other exotic tweeters, the

Cardinal was up against stiff competition. Yet there was no lack of extension, no edge or breakup modes to be heard. Nor was there any softening or smearing of high-frequency detail. On the contrary, texture and microdynamic shading on cymbal work, string harmonics and vocals were exceedingly natural and contiguous with the rest of the range, without being spot-lit or lifted. Tonal shadings were excellent, bringing real, identifiable character to different singers and instruments, but the most impressive element of all was the sense of substance. In the same way that air and harmonics were a natural extension of the instrument and notes producing them, the core of each instrument or voice had substance and identity, a real sense of direction and energy. Anybody who has heard a piccolo cut across an orchestral tutti will know exactly what I mean. The Cardinal manages exactly the same trick, embodying the smallest instrument with a solid presence, irrespective of what is happening around it.

In part at least, this is down to the seamless integration with that uncluttered, unimpeded midband, but it is also about the tweeter's ability to match that 180mm driver when it comes to delivering energy within its range. There's no ghostly, ethereal extension here -- just good old-fashioned life and energy. Yes, you get the air, purity and locational precision that come with superior high-frequency performance, but they are almost extras after the fact of the music -- another reminder that technical performance is all very well, but actually it's the musical performance that matters.

Putting it all together

By now, you will have realized that I rate the Cardinal very highly indeed. It is capable of remarkable levels of performance. But the key word in that sentence is "capable." Like any truly transparent loudspeaker, it is a slave to the system you hang it on the end of. The problem is that, just as the Cardinal doesn't sound the way it looks, the ideal choice of matching equipment is less than obvious too. To make matters worse, it flies in the face of conventional audio wisdom.

There's a deeply engrained compensation culture in audio. Got a bright-sounding CD player? Get some nice, dull, rounded interconnects and that will restore the balance -- at least so the logic goes. The problem is that those same interconnects will also slug and obscure the very qualities (brightness aside) that made you choose the player in the first place. This color-by-numbers approach is what often passes for system matching, whereas in fact it's actually completely the opposite, simply papering over the cracks. Faced with a speaker described as honest, self-effacing and (although I hesitate to use the term) neutral, a lot of dealers or listeners would reach straight for a valve amp to warm things up, and whilst there are valve amps that work with the Cardinal, it's not the driving device that's critical. It's the nature of the amplifier itself.

The beauty, the phenomenal strength of the Cardinal, is just how little of itself it adds to the process. Tamper with that aural invisibility and you throw the baby out with the bath water. In normal circumstances, nothing papers over system cracks (and obscures the music) more than the loudspeakers. The bigger the speaker and the more complex the crossover, the greater the potential damage, the greater the depth and spread of that sonic polyfiller. To get the best from the Cardinal you need electronics with a similarly shy personality -- amps that won't gate the demands of the musical signal (subtractive tendencies) or bend, add to or exaggerate it for effect (additive tendencies). Throw in an amp with a fat bottom end to pump up the bass weight and all you'll achieve is to undo all of the work that Wilson Benesch have put into the speaker -- and you've just paid for, assuming you own them.

I used a pair of VTL MB-450 Series III monoblocks with great success. They drove the Cardinals beautifully -- but not because they are valve amps. They succeeded because they ticked the right boxes. In turn, those are:

- **Power:** At 90dB sensitivity, the Cardinal's weakest suit is its dynamic range -- *if underdriven*. Unless the speaker receives sufficient power that arrives sufficiently quickly, it will sound flat and constricted compared to live dynamics. Of course, that will just place it in the same boat as most of the competition, but why accept ordinary when you can have extraordinary?

- **Delivery:** the crucial facility in making the '450s work with the Cardinals was their variable damping

factor, allowing better matching between driving amp and loudspeaker load.

- **Nature:** the '450's are neither overly warm nor romantic in nature. Instead, they are remarkably even top to bottom. Just as importantly, that evenness extends to their energy spectrum, a key factor in getting the best out of the Cardinal.

So, in looking for a matching amp, you are seeking large amounts of unfettered power that can be delivered across the full bandwidth -- from a clean, quick source. The best example of this came from the remarkable Siltech SAGA electronics, used to biamp the Wilson Benesch speakers, producing results that were really quite special. Seldom have I heard a system that can respond so easily and effortlessly to the demands of the musical signal. The uninhibited enthusiasm combined with the absolute honesty made for a winning combination that stopped several listeners in their tracks. But remarkable as they are, the four-box SAGA setup is also remarkably expensive -- a cool €100,000! At that price they should sound good.

So, is the Cardinal another of those speakers that isn't just expensive to buy, it's even more expensive to run? I achieved fantastic results from the Connoisseur 4.2LE/ Berning Quadrature Z combination at around half that price, but perhaps best value of all was the Avantgarde XA preamp and power amp, a combination that comes in the right side of €20,000 and also ticks all the boxes. This fully balanced, part battery, solid-state setup will be getting its own review shortly, but believe me, it's very, very good.

So when it comes to matching amps to the Cardinal, you are looking for quick, clean and above all uninhibited. And remember, however that amp sounds, you are going to hear it. But get it right and you'll be laying on the icing atop the musical cake. How does the Cardinal sound? By now you know the answer: It doesn't really sound at all, so devoid is it of inherent character. Yes, you need to encourage it, and yes, it needs that rarest of commodities, quick, clean power, but do the due diligence and it will reward you with musical performances that step away, not just from the speakers but from the system as a whole. Their limitations are those of bandwidth and capability, the price of honesty and the lack of glamour that goes with it. These are not dramatic performers; as I said earlier, they don't shout, "Look at me!" Instead they rely on the music and musicians to deliver the drama, a strength that is also potentially their greatest weakness. Many listeners will want more, will expect more. The ones who buy the Cardinal will be those who really get it, who understand that less really is more.

It would be possible to read this review and conclude that here you have a speaker that is admirable, honest, a bit bass shy, more intellectual than emotive in its presentation. Or, to put it another way, worthy rather than lovable. You could well conclude that, but you'd be wrong, and you'd be wrong for the same reasons that all our other assumptions about this speaker are wrong. You see, it is genuinely different; it doesn't fit that "accurate but boring" stereotype we've become so familiar with in the past. There is nothing pinched, sterile or bland about the Cardinal. It is rich of color in the same way that real instruments are rich: wholesome and solid with presence and energy that's refreshingly familiar. It's expressive, fluid and above all unobtrusive. If you want to hear your speaker, look elsewhere -- but if you want to hear your recordings, this is the real deal, not some pale imitation.

The cherry on the icing on the cake

When it comes to the bottom end, -3dB at 25Hz is not to be sniffed at, but the numbers don't tell the whole story. The Cardinal isn't, nor does it pretend to be, a genuinely full-range design. But before you dismiss it and move on, know this: It can be full-range, and surprisingly easily.

If you really want to hear what these speakers can do, then add a Torus Infrasonic Generator. Given the size (and price) of the Cardinal, you might well wonder why you should need to add a subwoofer, and what exactly a subwoofer can add anyway? Well, the answer to that is that the Torus is no ordinary subwoofer. Remember those issues with large-diameter drivers? Typically, Wilson Benesch have taken the bull by the horns and gone back to first principles. The result is a surprisingly compact "drum" 17" in diameter and a little over a foot tall. Lift the lid and you'll see a single upward-facing 15" carbon-coned bass driver, with a central boss that looks like it's from a pimped Caddy. What's so different? The Torus motor is a push-pull design with a voice coil either side of the cone. The motors are built onto a massive central post that serves as a mechanical ground, sinking energy directly to earth, rather than allowing it to enter the cabinet. The cone is incredibly stiff yet light, coupled to an unusually soft suspension. Control over the diaphragm is exerted by the motors, driven from an external amplifier/crossover box with plenty of real watts on tap and a large linear power supply. No wimpy class-D chipsets here! The result is astonishingly clean, fast and well-defined bass fundamentals from a package that is compact, elegant and, at £6400, refreshingly affordable for the performance on offer. I reviewed the Torus some years ago, as part of WB's Trinity system, and if I had the luxury of a settled system, the Torus would be an essential part of it. Instead, I'll have to settle for it being an essential add-on for the Cardinal.

Because Wilson Benesch weren't prepared to go for the "big-driver and added padding" solution to low-frequency weight, the Cardinal depends on speed and precision to deliver its bottom-end substance, a balance it strikes with remarkable success. Indeed, simply listening to the Cardinal won't leave you feeling short-changed -- until you hear it with the Torus. The main cabinets might be only 3dB down at 25Hz, but there's no mistaking what the Torus adds to the party. Play the moody, somber opening to Rachmaninov's "Isle of the Dead" [Jurowski/LPO 0004] and the Cardinals give you a convincing sense of space and presence, but add the Torus and the acoustic simply expands, taking on a new height and greater space between and around instruments. The bass notes offer more texture and timbre, with a blossoming of tonal color across the rest of the orchestra. All of which is to be expected from an orchestral heavyweight like this. But what you probably aren't expecting is the shift in pace and timing. Using the Torus makes the Cardinal on its own sound clipped and hurried, something you'd never pick up on listening to the speaker in isolation. Adding the bass unit brings a stability and anchored sense of timing that allow the music to swell and breath, to take on a more stately and far more effective tempo, transforming the emotional intensity and impact of this live performance. The Torus raises the Cardinal's already impressively communicative performance to a whole new emotive level.

The Torus couldn't do all that unless it integrated really well. The good news is that it does -- and does so very easily. Its preferred positioning, central between the speakers and the same distance from the listener to its center as to the speaker baffles, certainly helps, but there's more to it than that. The unit's clever design, super-stiff cone and astonishing level of control are what allow it to keep up with the Cardinal, while the lack of boxy coloration further

aids the seamless integration; if you want to know just how seamless, try it on something small and intimate. Those bass lines on "Little Triggers" become even more tactile, the drums more sudden, the song more affecting. Solo voices soar, while the acoustic space around recordings, already separate and distinct from the speakers, gains presence, boundaries, height and a floor -- at least it does if those details are on the recording. But it's the added fluidity, the increase in expressive range, that make what the Torus does not just impressive but essential. The Cardinal on its own is a

mighty impressive package. The Torus lifts it to a whole new level and does so without costing the earth. It also adds yet another arrow to the Cardinal's quiver, offering not just a genuinely full-range option, but a ready-made upgrade path from Cardinal to Torus to second Torus, serious musical improvements in bite-sized chunks.

The Cardinal's (relatively) limited bandwidth was all that stood between it and the high-end's top table. The Torus removes that reservation, emphatically, elegantly and cost effectively. The Cardinal/Torus combination deserves to be taken very, very seriously indeed. Don't let the price put you off; I know it's not as expensive as the competition, but price has never been a guarantee of performance when it comes to high-end audio.

Conclusions, conclusions

This is not just an impressive product, it is a loudspeaker that confronts the cost/content/performance question head on and delivers an emphatic response. In an industry and at a time when products just seem to get more and more expensive and those price tags are harder and harder to justify, the Cardinal is quietly saying, "We can do better." This is an industry that needs to listen to that message. Look at the proprietary engineering, unique materials technology and attention to detail in the Cardinal. Look at the total absence of any spurious BS. Now look at the price tag, and anybody who is anything other than seriously impressed either doesn't understand or is simply ignoring the economic realities of small-scale specialist manufacturing.

Of course, the interlocking set of technologies and capabilities that make the Cardinal possible are no happy accident and perhaps the most important thing to take from this review is that the flagship product is a natural evolution of the existing range. In other words, you find the same level of engineering excellence and thoughtful implementation right across the Wilson Benesch product line. The Cardinal might take it to the nth degree, but essentially the approach, materials and philosophy are there in every speaker the company produces -- in a range that starts at £2000 a pair.

If I had to sum up the Wilson Benesch Cardinal in a single word, that word would be integrity: the integrity of the people and company behind it; the integrity of the thinking that underpins the design, the manufacturing processes and materials that produce it; but most important of all, the integrity of the musical performances that it in turn produces. This is a tool, and like all really good tools, you'll recognize its quality as soon as you use it.

Price: £54,950 per pair.
Warranty: Five years parts and labor.

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Associated Equipment

Analog: VPI Classic 4 turntable with JMW 12.7 tonearm, Lyra Titan i and Dorian Mono cartridges, Zu Audio Denon 103 cartridge, Nordost Blue Heaven tonearm lead and Tom Evans Audio Design The Groove+ phono stage, Nordost Odin tonearm lead and Connoisseur 4.2PLE phono stage.

Digital: Wadia S7i CD player; dCS Paganini transport, DAC and uClock; Wadax Pre 1 digital control unit. Krell Cypher CD/SACD player.

Preamps: Avantgarde XA, Connoisseur 4.2, Siltech SAGA C1 Control Amplifier.

Power amps: Avantgarde XA, Berning Quadrature Z monoblocks, Siltech SAGA V1 Voltage Amplifier/ SAGA P1 Current Amplifier, VTL MB-450 III.

Speakers: Crystal Cable Absolute Arabesque.

Interconnects and speaker cables: Complete looms of Nordost Odin, Crystal Cable Absolute Dream or Ultra from AC socket to speaker terminals. Power distribution was via Quantum QRT QB8s or Crystal Cable Power Strip Diamonds, with a mix of Quantum Qx2 and Qx4 power purifiers and Qv2 AC harmonizers.

Supports: Racks are 26″-wide Stillpoints ESS (current and original versions) and LeadingEdge modular designs. These are used with equipment couplers throughout, either Stillpoints or Nordost SortKones. Cables are elevated on Ayre myrtle-wood blocks.

Acoustic treatments: As well as the broadband absorption placed behind the listening seat, I employ a combination of the LeadingEdge D Panel and Flat Panel microperforated acoustic devices. These remarkably simple yet incredibly effective acoustic panels have become absolutely indispensible when it comes to hearing what the system is actually doing.

Accessories: Essential accessories include the Feickert protractor, a USB microscope and Aesthetix cartridge demagnetizer, a precision spirit level and laser, a really long tape measure and plenty of masking tape. I also make extensive use of the Furutech anti-static and demagnetizing devices and the VPI Typhoon record-cleaning machine. The Dr Feikert PlatterSpeed app has to be the best ever case of digital aiding analog.