



# QUAD



## ESL-988 Electrostatic Loudspeakers

Ken Kantor (Acoustic Research, NHT, International Jensen, Vergence), who's been designing speakers for longer than anyone would like to remember anyone—including him—professes to be an avowed fan of electrostatic loudspeakers. *'I confess to getting a little bit light-headed when listening to really good panel speakers'* he wrote in the August, 1987 issue of the now-defunct US magazine *Audio*. *'Flat speakers share some important general characteristics [that] lend themselves to some of the best sound many of us have had the pleasure of hearing.'*

He's in good company of course. I doubt there's a speaker designer—or hi-fi reviewer—anywhere in the world who doesn't either own or have a soft spot for electrostatics. And when it comes to electrostatics, the most famous electrostatic loudspeaker in the world is the Quad ESL. Founded by Peter Walker in 1932 and kept in family hands up until only

ten or so years ago, Quad has recently changed hands several times, being owned first by Wharfedale and then by Verity before ending up with the present owner, International Audio Group.

Since purchasing Quad, IAG has been busy 'updating' the Quad ESL-63. However, for all this so-called updating, the final product (now known as the ESL-988) is basically just Peter Walker's original ESL-63 design with a new base and an upgraded power supply and transformer. IAG says that 95% of the components have been upgraded, which is true, because the old components in the circuits have all been replaced with the most modern (and superior) equivalents. The larger ESL-989 is a different story. Although it's based on the ESL-63, and is essentially just an ESL-988 with two additional bass panels, it's not—strictly-speaking—a Peter Walker design.

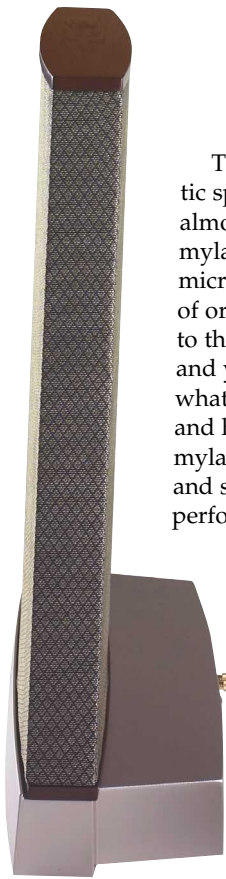
Electrostatic loudspeakers are the Ferraris of the audio world. For starters, it's very difficult to build electrostatic loudspeakers—so difficult that over the past eighty years, only a handful of manufacturers have been able to produce them in commercial quantities\*. I should qualify that by saying that it's difficult to build them to a consistent standard, and in volume.

Peter Walker was once asked whether he thought could improve the ESL-63 and said that he could easily do so as a one-off project, but that he could not do so in a production line situation.

Because the construction of an electrostatic loudspeaker does not lend itself to automated assembly, Quad ESL-988s are still built in England, and almost completely by hand. The speakers I received for review (Serial Numbers 901280 and 901281) were assembled by 'Guy', tested by 'Ivan' and packed by 'Lee and Ivan' at Quad Electroacoustics Limited, in Huntingdon, Cambs.

Because of their rarity, it's very possible that many readers might not be familiar with the operation of electrostatic speakers, so a brief explanation might be in order. Whereas conventional speakers depend on the interaction between a fixed magnetic field (created by the speaker magnet) and an alternating magnetic field (created by the current passing through the voice coil) to produce sound waves, electrostatic speakers depend on the interaction between different electric charges to produce sound.

[\*A cursory search of the Internet will reveal that at least 88 companies have in the past tried to make electrostatic loudspeakers, including some very big names in the speaker business. Very few lasted the distance however, and of those that did, fewer than ten ever produced more than a thousand ES speakers. Some, such as Braun, in Germany, merely licensed Quad's technology.]



The sound in an electrostatic speaker is produced by an almost massless sheet of mylar film that's only a few microns thick. Unwrap a roll of ordinary plastic food wrap to the height of a loudspeaker and you'll have a fair idea of what the mylar film looks like, and how much it weighs. The mylar is then stretched taut and suspended between two perforated metal plates, one

carrying a high-voltage positive charge and the other a negative charge. When an audio signal is applied (via a step-up transformer), the mylar moves back and forth, creating sound waves.

Because the mylar film has virtually no inertia and moves only a tiny distance, it

adds almost no distortion to the audio signal (less than 0.1%) whereas conventional magnetic drivers add up to 3.0% distortion under normal drive conditions, and up to 10% distortion when driven hard.

Perhaps more importantly, the tonal quality of an electrostatic speaker does not change with frequency because the same film produces both high and low frequency sounds, whereas in a conventional multi-driver system, the audio band is split between a woofer, a midrange driver and a tweeter, each of which stamps its own particular 'tone' on the part of the spectrum it's reproducing. This means that the sound of an instrument would be different depending on whether that instrument is making a low note (being reproduced by a woofer) or a high note (which would be reproduced by the tweeter).

There are also spatial considerations that arise when different frequencies are produced by different drivers. If a violin-

ist plays a low note, the source of the note will appear to come from the bottom of the speaker. If the violinist then plays a very high note, the source will appear to come from the top of the speaker. If the two speakers are further away than the size of a violin, the acoustic 'image' will be incorrect. Most loudspeaker designers locate drivers as close together as possible on the front baffle to get around this problem, but it must still exist in any multi-driver speaker system. With an electrostatic speaker, because the same film that produces the low frequencies also produces the high frequencies, the sonic image must be cohesive. (In electrostatic designs that use different panels for different frequencies, the two panels are always adjacent, and the panel areas are very large, so the problem still does not arise.)

That said, not all electrostatic speakers are equal. One design feature that sets the ESL-988 apart from all other electrostatic loudspeakers is that the electrical signal is delayed depending on where on the panel the sound will be reproduced. There are six concentric circles of electrode 'rings' on the ESL-988, and between each there's a circuit that causes a 20microsecond delay. The effect of this is that the soundwaves produced are delivered with a spherical wave pattern that mimics a perfect point source.

**Brand:** Quad  
**Model:** ESL 988  
**Category:** Loudspeakers  
**Suggested Price:** \$13,900.00  
**Warranty Period:** Five Years  
**Distributor:** International Audio Group Australia (IAG) Pty Ltd  
**Address:**  
 18/58 Box Road  
 Taren Point  
 NSW 2229  
**Tel:** (02) 9540 2469  
**Fax:** (02) 9540 2853  
**E-mail:** iagaus@bigpond.com  
**Web:** www.wharfedale-speakers.com  
 For additional information, turn to page 114 and circle 0281 on our Reader Information Service Card.

QUAD



Electrostatic speakers may create difficulties for manufacturers, but they also create difficulties for end users. One immediate problem is that they're highly inefficient, so you need a fairly high-power amplifier to produce reasonable sound levels. These days, obtaining such high power amplifiers is easy, except that there's another problem presenting electrostatic speakers, which is that their maximum output level is also relatively low, because it is limited by the breakdown voltage of the air itself. At sea level, this voltage (the dielectric strength of air) is nominally 29kV per centimetre, but can be affected by humidity and atmospheric contaminants (pollution, salt spray, etc). If the voltage is exceeded, the speaker 'arcs', discharging the diaphragm and possibly damaging it and/or the electrode. The Quad ESL-988s have protection circuitry built in that prevents them from being overdriven, by simply shutting down the panel when the voltage gets too high.

It's because of this protection circuitry that you must exercise a

degree of care when selecting an amplifier to drive the Quad ESLs. The reason being that when the in-built protection circuit triggers (and I say 'when' rather than 'if' because the circuit will certainly trigger from time to time) the speakers will effectively present as a short-circuit to the amplifier. If the amplifier does not have its own internal short-circuit protection, it is highly likely to be damaged. Therefore, you should not use any amplifier that does not have fast and effective short-circuit protection. Note that when I say short-circuit protection, I do not mean a fuse! Apart from the fact that transistors often fail before the fuses that are designed to protect them, output stage fuses are normally located 'inside' an amplifier, where they can't be replaced by the owner.

In terms of power output, the amplifier should be rated between 50-watts and 120-watts continuous per channel (into 8 ohms). The reason for the lower limit is simply that the ESLs are so inefficient that you won't get appropriately loud volume levels with anything less. The reason for the upper limit is that the Quads will just turn themselves off if the input voltage exceeds 30 volts, and a 120-watt amplifier is all you need to deliver 30 volts. It is also important that the amplifier is happy driving highly capacitive loads, because the ESL-988 will look like a big capacitor to the amplifier's output stage.

### Listening Sessions

It's quite a long time since I heard a pair of ESL-63s, but the memory of those sessions is burned into my brain, and I can say unequivocally that the new ESL-988s are noticeably improved over the original '63. The most obvious improvement is in sound pressure level—the ESL-988s simply play much louder than the older 63s. They're so loud that I'd guess that in most ordinary-sized living rooms, it will be possible to attain concert-hall volume levels fairly easily. However, if you have a very large living room, or an open-plan design home you will find the highest volume level you can achieve may not be loud enough for

you. And if your idea of musical heaven is house music at 100dB SPL, you and the Quad ESL-988s will certainly not be a match made in heaven. The best part of this is that it's very easy to ascertain whether the Quads will play loudly enough to suit you before you buy a pair. It's simply a matter of putting the speakers in a showroom the same size as your listening room and asking the dealer to crank up the volume whilst playing back your usual music. If you throw in the towel before the speakers, you will have your answer within a few seconds. One word of caution, though: the distortion levels of the ESL-988 are so amazingly low (or, if you prefer, the sound is so beautifully clean) that unless you monitor the sound level with some type of external reference (such as constantly checking to see if you can hear yourself speak over the music) you will probably find that you are listening at far higher levels than you would normally listen. If you're going to try this test, take the time beforehand (that is *before* you blast your ears) to listen to the ESL-988s at very low, almost background levels, so you can be stunned by the effortlessly detailed performance at these levels. Given that it's likely you'll do more listening at low to medium levels than louder levels, the superior performance of the ESL-988 at low levels cannot be overemphasised. I suspect this is just a trait of electrostatics, which by virtue of their operating principle respond instantaneously and have very low mass. A conventional speaker, on the other hand, has to deal with hysteresis problems and the fact that the mass of the speaker—and the compliance of the surround—are more significant at low voltage drive levels than they are at high ones.

My second surprise with the ESL-988 was the strong, powerful bass delivered by the panels, which was more extended than I remember being delivered by the ESL-63s. This may have been partly due to the room and/or the room placement (the room I listened to the ESL-63s in is no longer available to me) but it

may also be due to the stiffer frame (something Quad says it's paid particular attention to) and the stronger, heavier base. Whatever the reason, the proof is in the pudding, and the bass is particularly good. Bass freaks will feel the need to add a subwoofer, but then they'd feel the need to add a subwoofer to any speaker system! That said, bass response is not one of the ESL-988's strengths, which I guess is the reason for the development of the ESL-989 with its extra bass panels—there'd otherwise be no reason at all for its existence!

To prove the ESL-988 was full of surprises, the upper treble response was also slightly improved. What wasn't a surprise was that you need to be really, *really* careful placing the speakers in the room and in aiming them very accurately at your listening position. There is most certainly a 'sweet spot' for the extreme highs with the ESL-988s and if you don't sit in it, you'll miss out on the best highs. In most situations, you will have to tilt the speakers backward to get the treble aimed at your ears when you're sitting down. You certainly won't get the right sound when standing up, so don't even try a quick showroom audition in this position. My favourite listening position quickly became a low seat about three metres from the speakers.

As for the Quad ESL-988's midrange, what can I say? It's perfect. It's perfectly flat, perfectly linear, perfectly neutral, perfectly open, and perfectly detailed. Yes, that's a rave and I know it sounds a bit over the top, but it's a very accurate description of the sound across the midrange. I A-B'ed back and forth between the Quads and a variety of very expensive, highly credentialled conventional (dynamic) loudspeakers and although they could equal (and sometimes better) the Quad ESL-988s in the bass and also the treble, not one of them could hold a candle to the Quads across the midrange. Switching back to any one of them from the Quad was like someone was drawing a curtain across the stage. One of the 'review' discs I use in my evaluations is 'A Feather on the breath

of God' which consists of sequences and hymns by the abbess Hildegard of Bergen (Hyperion CDA66039) and while I was listening to it, I felt the title of the CD also perfectly described the midrange sound of the ESL-988s. It too, truly is like a feather on the breath of God.

In many ways, I think I am doing the sound of the ESL-988s a disservice by dividing it into bass, midrange and treble and discussing each in turn in this review, because the ESL-988's greatest strength is that when you're listening, you are not conscious of the distinction, in fact it's enormously hard to hear when the bass stops and the midrange begins, and the same for the mid/treble transition. For all practical purposes, these transitions don't exist in the ESL-988's sound. Instead, the whole audio spectrum seems to just 'appear' in the room, as a musical event, rather than a recreation of an electrical signal. The sound is gloriously detailed, and the music reproduced so transparently it is really as if there are musicians in the room, instead of just a pair of speakers. This impression is reinforced by the fact that when a crescendo comes along, the tonal quality of all the instruments involved remains exactly the same: all you hear is an increase in volume. This isn't what happens when listening to conventional loudspeakers. With dynamic loudspeakers, distortion *always* increases with increasing level, so music sounds a little 'harder' during crescendos. With the Quad ESL-988s, distortion is not only lower to start with; it stays low irrespective of volume.

### Conclusion

Quad's ESLs (whatever their model number or vintage) have always been 'ugly ducklings' and I don't think the ESL-988s have progressed one iota in the appearance stakes. And unfortunately, unlike the ugly duckling, they don't get more beautiful with age. But it really doesn't matter, because once you've heard them, the beauty of their sound will blind you forever to their appearance.

greg borrowman

Readers interested in a full technical appraisal of the performance of the Quad ESL-988 loudspeakers should continue on and read the 'LABORATORY REPORT' published on the following pages. All readers should note that the results mentioned in the report, tabulated in performance charts and/or displayed using graphs and/or photographs should be construed as applying only to the specific sample tested.

lab report

### Test Results

The frequency response of Quad's ESL-988s was very good, as you can see in *Figure 1*, but not outstandingly so. Across the all-important midrange, the response was within 1 dB from 300Hz to 8kHz. The slight 'bump' in the response at around 100Hz is most likely a measurement/room artefact, and if it's included in the tabulated figures, it limits the overall  $\pm 3$  dB response to 45Hz in the bass and 8.5kHz in the treble.

However, if you accept that the bump is an artefact and ignore it, the lower limit is pushed down to 30Hz and the higher limit out to 14kHz. Overall, that's 30Hz–14kHz  $\pm 3$  dB, for those not paying attention. The high-frequency roll-off graphed is not unexpected from this design, but the steepness of the slope indicates the measuring microphone may not have been *exactly* aligned with the panel and, with a panel electrostatic, if the alignment is not perfect, the high frequencies will certainly disappear.

The second graph, of impedance, shows the resistive part of the ESL-988 is quite benign, dipping below 4-ohms only between 10Hz and 18Hz and again at 10kHz and otherwise averaging around 7-ohms over most of the audio band.

The sensitivity of the Quad ESL-988s was measured at 82 dB SPL for a 2.83V input, using *Australian HI-FI Test Laboratories'* standard test conditions and procedures. This is inefficient by any standard, so even though in his review, Greg Borrowman recommends an amplifier with a 50-watt minimum power output, I would per-

sonally recommend an amplifier rated at at least 100-watts continuous per channel. The panels shut down quite quickly when tested with continuous sine waves or with high-level pink or white noise (which showed that

Quad's protection circuitry works) but it was more reluctant to shut down when driven by high voltage music signals, which is as it should be. Nonetheless, I would not recommend trying to 'burn-in' the speak-

ers with test or burn-in CDs. With electrostatics, burn-in is completely unnecessary, any way. All you have to do is leave the speakers switched on all the time. <sup>AKI</sup> Don't try to play the speakers when the panels are not

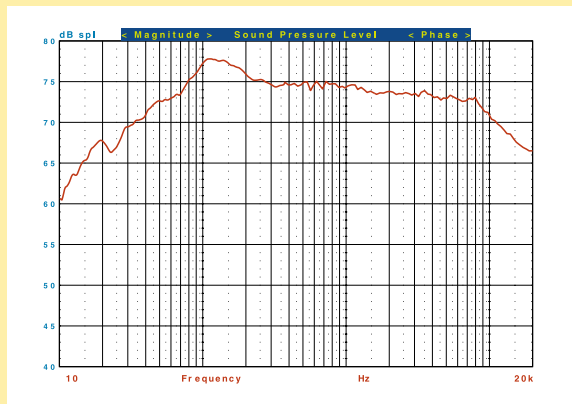


Figure 1: Frequency response @ 1 watt @ 1 metre

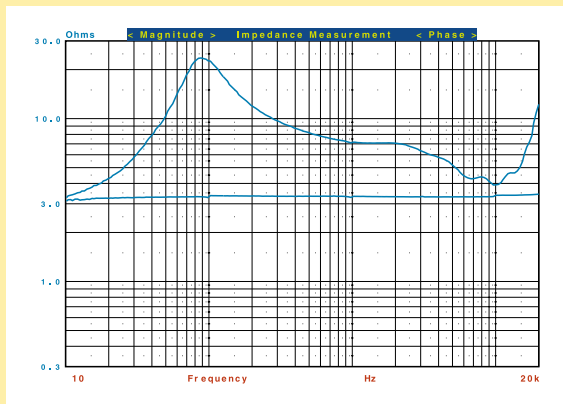


Figure 2: Impedance vs Frequency