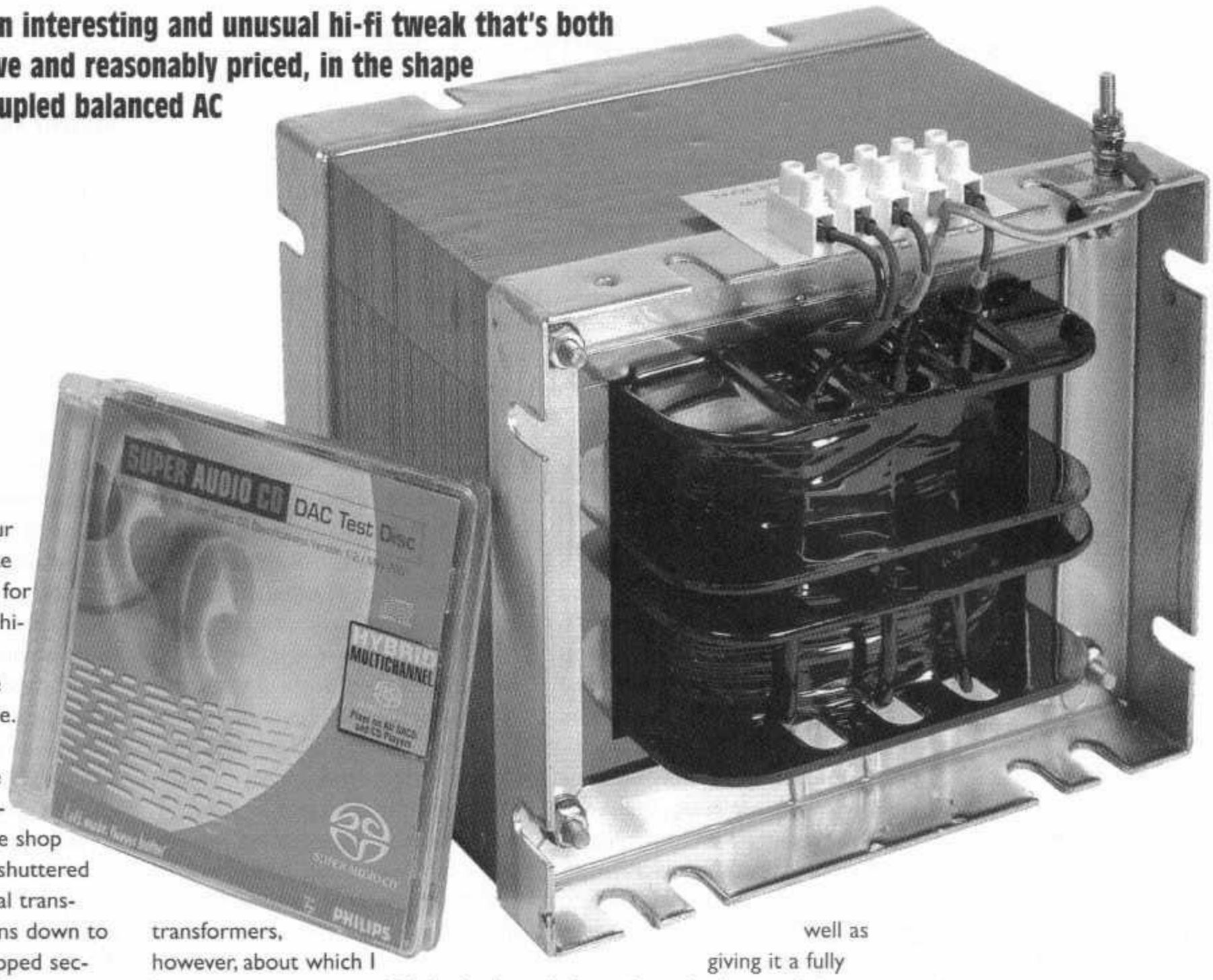
Balanced Thinking

Noel Keywood has an interesting and unusual hi-fi tweak that's both dramatically effective and reasonably priced, in the shape of a transformer-coupled balanced AC mains supply.



Straight from your local building site comes this idea for improving your hi-fi - and it isn't a slab of concrete to put under the turntable. Up one level in building site technology is the site safety transformer, on display in your local HSS hire shop as a big, yellow box with shuttered outlets. Inside lies a special transformer. It steps 230V mains down to 110V and has a centre tapped secondary. The idea isn't to get a purer sound from a Kango hammer, so much as to deliver no more than 55V or so relative to ground to avoid shock, even in the wet.

Improving safety isn't much of a priority in domestic hi-fi as it's safe enough, but this idea, albeit in different form, has other advantages. By reducing ground currents and noise it reputedly can improve the sound of a hi-fi system quite dramatically. But like all things hi-fi, there are those who talk it up and those who pooh-pooh the idea. The theory seemed sound enough to me, all the same, and at worst I could only blow up the television, computer and hi-fi all at once, so I picked up the telephone to order a transformer...

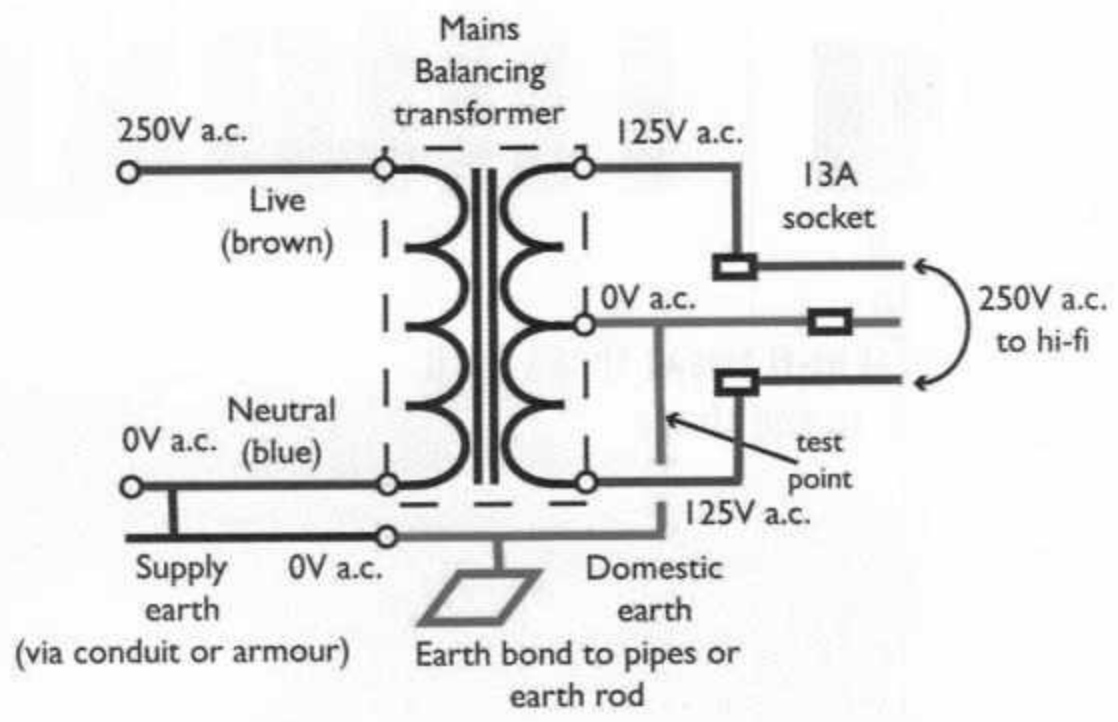
The idea of balancing the mains to reduce noise, hum and various ills in professional sound equipment - especially studios - isn't new, but so far it isn't an idea that's gained traction. If you want to read more, just take a look at http://www.equitech.com/, a U.S. company that specialises in supplying balanced power. They use toroidal transformers, however, about which I have great reservations. We ditched toroidals in World Audio Design amps some time ago, taking good advice to go back to proper frame transformers (AKA E/Is) for best results. They're heavier and more expensive, but do the job better. I'm no transformer expert though and was prepared to take the advice of our transformer company, who not only wind fantastic audio transformers, but also happen to specialise in big power transformers, which are another area altogether. You can see what they came up with in the picture - lovely isn't it?

I should point out that this 35kg block of iron - a two man lift - isn't identical to a site transformer. It is similar in having a centre tapped secondary, which gives 125V relative to ground from a 250V supply, so it improves safety, but that is a side issue here. Site transformers step down the voltage; this one does not. It has a 250V output. It is also constructed specially to give a performance appropriate to its particular task, which means isolating the hi-fi from mains-borne noise as well as giving it a fully balanced supply, the two being different. What I wanted to know is, would it improve the hi-fi, or blow it up?

SAFE HOUSE?

Perhaps this idea hasn't gained traction because it seems risky. This is ironic because it is in principle safer, but neither I nor experts at the Institution of Electrical Engineers, responsible for our Electrical Wiring and Safety Regulations, could be at all sure how items connected up to a centre tapped mains supply would respond. I asked them and they suggested any items connected should be 'suitable'. Er, yes, quite. Since the live and neutral wires of our mains supply are always treated as being live, even though neutral (blue) is earthed, it should all work well. Smoke would only appear if there was any ground referencing in the primary circuit, which there never is (I told myself)...

Building valve amplifiers has equipped me with a healthy fear of the mains and high voltages. Worse, for this project I realised I would



How it works: the mains enters from left in this diagram, via usual Live and Neutral wires. The secondary winding, at right, delivers 250V out, but it is centre tapped to ground. This gives a balanced output that cancels ground currents, measurement shows.

have to connect a spectrum analyser to the mains, something that would produce a very expensive puff of smoke if I got it wrong. My best friend and defence in situations like this is a large variable voltage transformer (Variac) capable of delivering 4amps. With this I could wind up the volts slowly and watch or smell for signs of distress, a precaution I routinely take with prototype valve amps.

The big question was: would a balanced mains supply evaporate the hi-fi, TV and computer? Initially, I gingerly wound up the Variac, praying that I wouldn't be greeted by that nasty burning smell you get from tortured electrical devices as they expire - but nothing happened. The Philips TV came on normally, the hi-fi had no problem with it and a whole bench of test equipment fired up and ran perfectly. Sure enough, a voltmeter showed just 125V relative to ground on live and neutral, but in spite of this complete rearrangement of working conditions everything worked perfectly. A Mac Mini computer and a home brew PC (switch mode supplies) were happy too, as were all its peripherals, like disc drives and what have you. A Belkin Ethernet wireless bridge lost its settings in protest, but after my usual mutterings and cursings over its infernal set-up procedure, it popped back up on the router's DHCP Client Table, working properly. So it had survived too.

The transformer manufacturers asked me to run their beastie flat out to check voltage droop, and core and copper losses. It was specified to have superb regulation and run cool (much less than 130 degrees C) under full load, so I ran two electric fires and a hi-fi system from it for hours, drawing a full load of 10A, without the windings getting anything other than warm. The core gets quite hot though (I would guess 50-60 degrees), even with no load, because the primary is low impedance. This has to be accepted, since increasing turns would have run the core cooler at the expense of regulation. We used good grade laminations; top grade would have reduced core losses and heat a little - about 20% - at increased cost.

I could say this was a real industrial grade transformer, but it wasn't - it was higher than that. It was audio grade, as the designer knew I wanted top dollar regulation, conservative core temperature, good lamination quality, and heavy gauge copper windings to minimise full load heating. He chose a twin bobbin arrangement to give loose mains coupling, in order to minimise noise and interference transmission. You can see this construction in the picture. Transformers are normally wound coaxially, one winding on top of the other, giving tight coupling. Separate bobbins gives more room for heavy copper windings, with lower heat retention and better regulation. This was an audio special that performs better than would normally be considered necessary, and far better than industrial grade - we don't want any of that!.

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SOUND TRANSFORMATION?

At first, having got everything fired up I was slightly puzzled. There seemed to be a subtle cleaning and clearing of the sound, but with LP it wasn't great, although that is not to say not useful. I then realised that the record playing equipment I was using wasn't likely to be so affected by the reduction in mains related earthing currents and such like as modern solid-state equipment, something that measurement confirmed with surprising certainty. A Denon DVD-2900 player I use showed exactly the same benefit with CD, but to a greater degree. I should be excited, but it brought an added depth to the sound stage here that moved it up dangerously close to an Ortofon Kontrapunkt moving coil cartridge, albeit running through a lower quality phonostage.

After a while I felt that benefits were certainly there and worth having too; it was akin to using a good preamplifier. The extra sense of depth and space with CD were subtle but persuasive. I felt at this point that the improvement wasn't as large as I'd hoped for, but suspected they were likely to be equipment related and, possibly, the items I was using weren't deficient in their power supplies. Subsequent measurement provided some interesting support for this view.

A balanced mains supply is meant to reduce earth currents, and the multifarious problems they cause. A lot of ills are blamed on earth currents, as both design and studio engineers know from bitter experience that all their best hopes and efforts can be dashed by unaccounted for earthing problems. Let's just say that earth currents are the bane of good audio, as tech. talk on all this is endless, as well as abstruse. Prodding around the system with a spectrum analyser I noted that my mains supply was delivering 250V, with 4% distortion, predominantly fifth order due to current draw at peaks by equipment outside my home, as I switched everything off before measurement. An extended harmonic structure looked much like

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digital distortion. Switching on an entire hi-fi system did not change this one bit, with or without the transformer in circuit. This surprised me a little; I expected some small change, but I do have a stiff supply, as all house cables and the street supply are relatively new, and a low impedance supply will be resistant to change (i.e. have good regulation).

But as a balanced supply is meant to affect earth currents, perhaps I was looking in the wrong place. Consequently, I inserted a 4 ohm resistor in the earth line on a system and connected the analyser across this to sense earth currents, with and without the transformer. The result was fascinating. In conventional unbalanced mode I measured a paltry 100uV across it, at 50Hz, with everything blazing away. This is hardly large; I had expected at least a few millivolts, or ten times as much. But things were to get a little interesting. I switched off my WAD 300B valve amplifier and the figure dropped just 2uV or so, where I had expected it to collapse, because valve amps draw current. It proved to be my Denon DVD-2900 and Aqvox phono stage were contributing most to the earth current flowing, I presume due to earth leakage in their mains transformers. Whilst we've always used the best transformers possible in WAD valve amps I didn't quite expect my venerable 300B to produce virtually no earth current, as it's mains transformer produces massive H.T. voltages and large heater currents, raising the likelihood of large earth currents, at least, larger than you'd expect from a DVD player. So this matter of earth current isn't quite what you might expect, suggesting the results you get going balanced will be varied and difficult to predict. But what of balanced power?

This was even more surprising; the earth current disappeared almost completely when the balanced transformer was put in circuit, measuring a miniscule 5uV across the 4 ohm resistor. Now, switching on the Denon and Aqvox had no affect; the figure stayed resolutely at 5uV no matter what I switched on or off. I was expecting the TV to be a sinner, but it wasn't, which perhaps explains why balancing did not appear to improve picture quality, as is often stated.

Quite obviously, balancing does alter earth current behaviour quite dramatically, virtually eliminating earth currents completely it seems. In my set-up, the currents were very small, but I suppose they should be. The corollary here is that in any set-up with large earth leakage currents, for whatever reason, installing a balanced supply is going to have a large affect. So whilst what I heard was subtle but useful, especially with CD, others might gain much more. Perhaps this is why balanced power is often seen as a magic bullet, capable of curing the most intransigent audio ills.

I did ask the manufacturers what sort of tranny would be needed to power a house, typically drawing 60A at full trot, but was told it would need a crane. A large hi-fi and TV will likely draw 4A, or thereabouts, and a transformer of this rating (1kVA) is liftable and not too large. My little monster is a reviewer' special, proportioned to avoid limitation. I will continue to run my system from it, but as it draws 150W or so at no load, it will be switched off when not in use; there are disadvantages too.

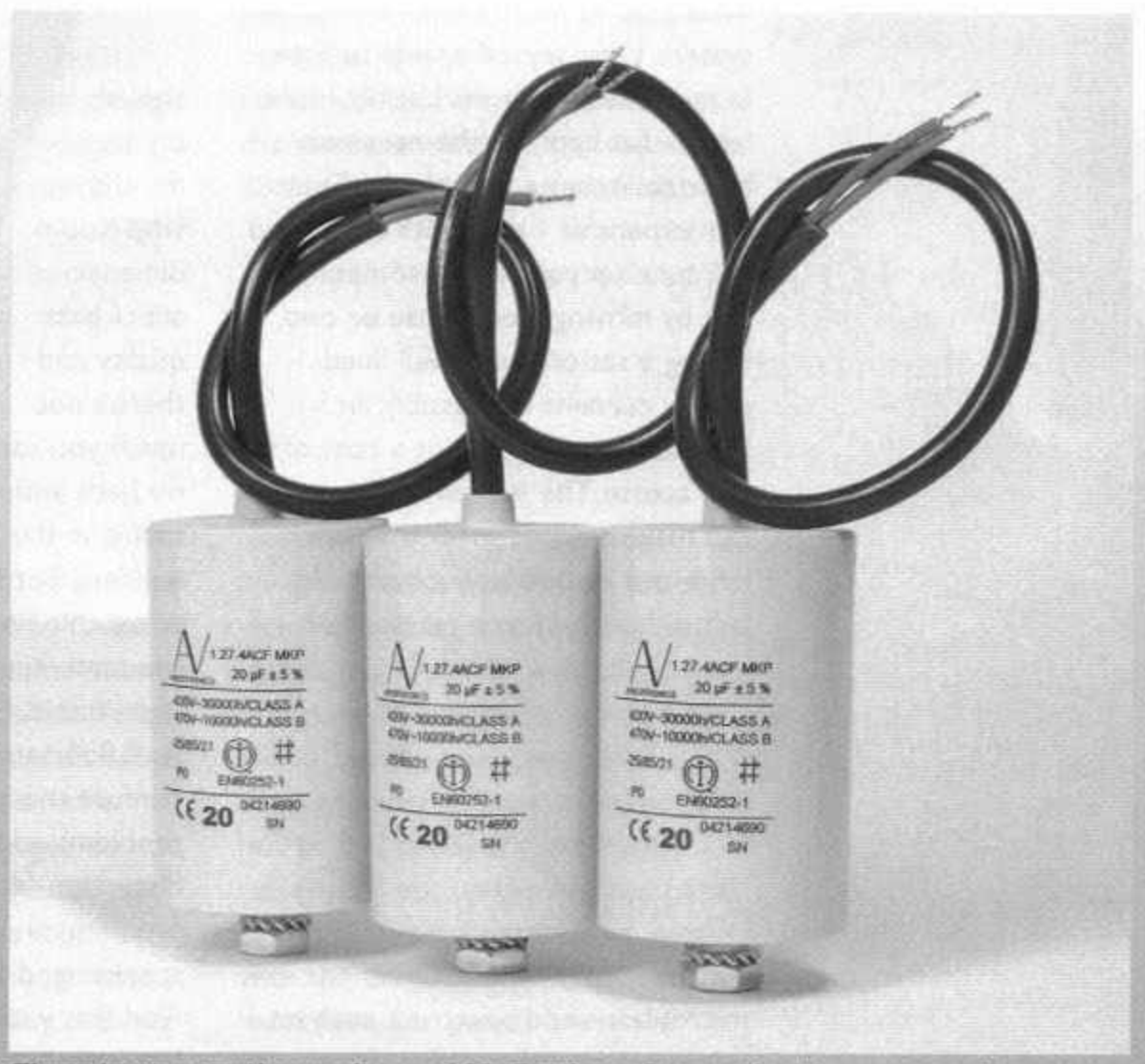
I intend to run two test benches from balanced supplies, as here is an area where miniscule voltages and currents are commonplace, making stray leakage currents strictly unwanted. But the reason balancing is becoming an issue in testing is because 24bit resolution digital audio demands ultra low noise, in theory down to 0.12uV if a full 144dB is to be realised. This is a little academic perhaps, but all the same it explains what's driving the idea of balancing in audio - including the mains supply. Soon, perhaps, something resembling a site transformer will become common in the home, as a balanced supply is a good way to run a hi-fi, as well as a Kango.

SAFETY FIRST!

A domestic balancing transformer should be housed in an earthed steel case, for safety and to constrain its magnetic field. The Institution of Electrical Engineers say a suitable residual current circuit breaker in both live and neutral output lines is a good idea for safety; both are live lines in this case. Residual current circuit breakers, or RCDs, trip out when there's overload or current imbalance between the live and neutral conductors, meaning current to earth somewhere - they reduce the likelihood of electrocution.

The 125V of a balanced system such as this one is still potentially lethal, although current through the body is halved. As accidents commonly arise from poorly executed electrical wiring, tinkering with the arrangement I have described is in itself a dangerous business. And whilst I didn't blow anything up, that's not to say it could not happen, although I think it highly unlikely.

The Institution of Electrical Engineers also say that both live wires should be brown as they are both phase conductors; there's no blue wire or neutral. Also, if you do decide to have a go the Institution of Electrical Engineers say don't forget the most important wire of all, the green-and-yellow earth conductor; your safety may depend on it.



Three 'motor start' capacitors, of 20uF apiece. Connecting them across the secondary of the balancing transformer filters out mains borne noise and interference. This is another way to lessen noise input to the hi-fi system. Motor starts are high voltage polypropylene capacitors suitable for power work.