Elliott Sound Products Cables, Interconnects & Other Stuff - The Truth

Page Last Updated - 24 August 2001

ESP Home Page
Articles Index

Contents

Introduction

So much has been said about cables of the past few years that there couldn't possibly be any more to discuss. Nice theory, but the wheel has turned a full circle, and there are now people claiming that there is no difference at all between any speaker cable or interconnect. In exactly the same way as the claims that there were "huge differences" were mainly false, so are claims that there are none.

There is no "black and white" in this topic, but a great many shades of grey, and the latest update to this article attempts to clarify the position. Speaker cables in particular are still a major topic of conversation on many forum sites, and remain one of the more contentious issues.

A quick summary of the topics to follow (in the cable discussion, at least) would be ...

- Power leads will rarely (if ever) have any effect on the sound, provided they are of reasonable construction and are not inducing noise into (unshielded) interconnects. The only exceptions are those that use filters of some sort, which will reduce the noise floor in areas where interference is a problem.
- Speaker cables *can* (and sometimes do) sound different with a given amplifier and loudspeaker combination, even where they are well designed and of reasonable guage. Excluded are very thin or extremely silly combinations - these will always do something to the sound, rarely good.
- Interconnects *might* sound different, but only if they use odd construction techniques. Generally speaking, all well (sensibly) designed and well made interconnects will sound the same - excluding noise pickup which is common with unshielded designs.

This is not to say that some people will not derive great enjoyment from the fact that they have spent as much on their cables as mere mortals can afford for their whole system, but this is "enjoyment", and has nothing to do with sound quality. This is about prestige and status, neither of which affect the sound.

Preamble

The last link entry for the ABX Home Page has been included so you can have a look at some actual ABX double blind tests that have been carried out. The listing at the ABX site is not extensive, but is excellent reference material. You will find some of the results surprising, and when viewed and interpreted sensibly, they tend to support the comments I have made in this article.

In some cases, the results surprised me, in that I was expecting the listener panel to declare various items as different, and they instead thought they were the same (which is to say that the two items under test could not be identified with certainty, so any choice was pure guesswork).

In this article, I shall attempt to explain some of the misconceptions and untruths that are rife in the audio industry. This article is bound to offend some, but the information is based on fact, scientific data and the results of my own (and others') testing, plus the help I have received from readers, who have provided more information on a number of topics.

In contrast, much of the disinformation comes from the rantings of Hi-Fi reviewers, most of whom know so little about electronics that it is shameful (and fraudulent) for them to be in a position to tell the unsuspecting public what to buy, based on entirely subjective criteria.

In almost all other areas of human interest, objective measurements are paramount. A domestic vacuum cleaner's performance is based on how much dirt it collects from the carpet - any philosophical discussion about the type of motor used, or it's rotational direction having a subtle effect on how clean the carpet feels is at best a pointless and tiresome exercise, and (I hope) has never been entered into.

Discussion - indeed, heated debate - on parameters not dissimilar to those above are commonplace in the high end audio industry, and have been raging since the late 1970's. The majority of people who listen to music generally listen to a few systems at a non-specialist retail outlet, and buy a combination that sounds good (to them), has the features they want, and fits their budget. They are no more interested in the great audio debate than they would be in the philosophy of the rotating mechanical components of their vacuum cleaner.

In his article "Science and Subjectivism in Audio", Douglas Self [1] wrote

> A short definition of the Subjectivist position on power amplifiers might read as follows:
>
> - Objective measurements of an amplifier's performance are unimportant compared with the subjective impressions received in informal listening tests. Should the two contradict the objective results may be dismissed out of hand.
> - Degradation effects exist in amplifiers that are unknown to engineering science, and are not revealed by the usual measurements.
> - Considerable latitude may be used in suggesting hypothetical mechanisms of audio impairment, such as mysterious capacitor shortcomings and subtle cable defects, without reference to the plausibility of the concept, or gathering any evidence to support it.
>
> I believe this is a reasonable statement of the situation. Meanwhile the overwhelming majority of the public buy conventional hifi systems, ignoring the expensive and esoteric high-end sector where the debate is fiercest.

In the following article I shall disect some of the claims made on many of the components in the audio chain, and show why they are misleading, false, and in many cases downright dishonest. See Further Reading for ... well, further reading.

This was submitted by a reader, and originally published in the New York Times (on-line edition) a while ago ...

http://www.nytimes.com/library/tech/99/12/circuits/articles/23down.html

December 23, 1999

A Spat Among Audiophiles Over High-End Speaker Wire

By ROY FURCHGOTT

In the last year, Lewis Lipnick has tested high-end audio cables from 28 manufacturers. As a professional musician with the National Symphony Orchestra and as an audio consultant, he counts on his exacting ear to tell him if changing cables affects the accuracy of the sound from his $25,000 Krell amplifiers.

His personal choice is a pair of speaker wires that cost $13,000. "Anyone would have to have cloth ears not to tell the difference between cables," he said.

"In my professional opinion that's baloney," said Alan P. Kefauver, a classically trained musician and director of the Recording Arts and Sciences program at the Peabody Institute of Johns Hopkins University. "Has the wire been cryogenically frozen? Is it flat or round? It makes no difference, unless it makes you feel better." His choice for speaker wire? Good-quality 16-gauge zip wire.

The disagreement would be unnotable except for one thing: experts are in agreement that most cables that claim to improve the sound of audio equipment don't. Even cables costing thousands of dollars per foot are often little more than sonic snake oil, experts say. Consumers trying to purchase audio cables often find themselves buying high-end replacements because the only cables in the store are expensive ones.

A purchaser of an entry-level $550 stereo system might be sent home with $55 worth of the least expensive middle-quality audio cables. While experts agree that most cables make exaggerated and unfounded claims about improving sound, they cannot agree on which cables actually do improve sound and which do not.

The scientific record is unclear. So far no research paper contending to prove or disprove the value of fancy wires has been accepted by the leading industry publication, The Journal of the Audio Engineering Society, said Patricia M. MacDonald, its executive editor. She said there were dozens of reasons a research paper might not meet her journal's standards.

"I don't think anyone should infer anything from it," she said.

The manufacturers and sellers of audio goods like to stay above the fray. Cables are a highly lucrative item that may account for a modest percentage of sales but a greater percentage of profit. Even audio manufacturers not directly involved in the cable business like to steer clear of the debate.

[Related Articles: Do It Yourself: A Little Soldering Goes a Long Way; (December 23, 1999)]

Polk Audio, a well respected manufacturer of loudspeakers in Baltimore, no longer makes cables but declined an invitation to set up a listening test in its laboratories. One reason it gave was that the test could affect relationships with audio stores. "We would be hearing from every retailer in the country," said Paul Dicomo, communications director for Polk Audio. Kerry Moyer, staff director for the Consumer Electronics Association, which represents manufacturers, said accessories were usually the highest markup items, wires included. Sales of high-margin accessories have become critical in the current market, where prices of components like receivers, amplifiers and DVD players, have had profit margins squeezed by competition.

"It becomes a question of where are we going to make a little money?" he said. Mr. Moyer, whose $3,000 sound system uses about $300 worth of cables, said the technological superiority of a cable is not the issue -- it is the perceived value to the hobbyist.

"If someone feels good about buying it, whether it works or it doesn't, it makes them feel good," he said. "I don't think we should question."

John Dunlavy, who manufactures audiophile loudspeakers and wire to go with it, does think questioning is valid. A musician and engineer, Mr. Dunlavy said as an academic exercise he used principles of physics relating to transmission line and network theory to produce a high-end cable. "People ask if they will hear a difference, and I tell them no," he said.

Mr. Dunlavy has often gathered audio critics in his Colorado Springs lab for a demonstration.

"What we do is kind of dirty and stinky," he said. "We say we are starting with a 12 AWG zip cord, and we position a technician behind each speaker to change the cables out." The technicians hold up fancy-looking cables before they disappear behind the speakers. The critics debate the sound characteristics of each wire. "They describe huge changes and they say, 'Oh my God, John, tell me you can hear that difference,'" Mr. Dunlavy said. The trick is the technicians never actually change the cables, he said, adding, "It's the placebo effect."

This leads to disagreements based on competing science. Bruce Brisson, who owns Music Interface Technology, an ultrahigh-end wire manufacturer in Rockland, Calif., also wants to see cable charlatans revealed and may use his extensive laboratory to do it.

"I am getting ready to expose this in the year 2000," he said. "People are paying a lot of money and getting nothing for it." But he disagrees with Mr. Dunlavy on the effectiveness of wires, saying that the theory Mr. Dunlavy uses to design his cables is not the right theory and that is why listeners cannot hear a difference. **

Some scientists say it would be difficult to prove one way or another. Changing cables leaves a time lapse that makes comparison difficult. Putting several stereos side by side with the different wires would mean that the speakers would be different distances from the ear, which could have an effect. And while a switch could be made that would send a signal through each of several cables to a speaker from a single sound system, cable makers say the switch itself might spoil the advantages of their wires.

Part of the difficulty is that there are still unexplained acoustic phenomena. William Morris Hartmann, a professor of physics at Michigan State University in East Lansing, works on psycho-acoustic projects, which investigate the way sound is perceived, rather than the way it is produced. There are examples, he said, of sounds that measure beyond the range of human hearing, and yet some people seem to perceive them. That means the market is left open to wild claims and psuedoscience. "It's annoying, but it's hard to disprove," Professor Hartmann said.

Perhaps the closest thing to middle ground is the position taken by Russ Hamm, an electrical engineer whose New York company G Prime Ltd. installs digital processing equipment for studios. Mr. Hamm said that indeed, wires do make a perceivable difference, but very little, and then only to professionals, like the engineers at BMG Music. He
lent them new high-grade cables for use on roughly $250,000 of equipment. On his system, Mr. Hamm uses a specialty cable manufactured in Vienna that costs $2 a foot.

"We are talking subtle differences, but that is what the high end is all about," he said.

It is a subtlety he describes as a 2 percent difference on a high-end system. "If you had a fine Bordeaux wine, how much does it matter if it's in a nice wineglass or a Riedel crystal glass?"

His advice to audiophiles: "I would say that you want to put the first $10,000 into your equipment."

The above is reproduced verbatim, and I hope that this information is helpful to your understanding of the topics to follow. Remember that the purpose of this article is *not* to try to sell you something, but to inform and rationalise the many myths that abound regarding the audibility (or otherwise) of different cables.

** It is worth noting that the year 2000 has come and gone, and to my knowledge, neither Bruce Brisson nor anyone else has produced a scientifically sound explanation for the alledged superiority of any one cable over another. There is simply little or no validation available for the vast majority of the outlandish claims made.

Power Cables

This seems to be a good place to start, since this is how power gets to your system. There are mains cables (power cords) out there that defy belief. Would you spend US$3000 for a 2 metre mains lead? You can buy a very nice amplifier indeed for this sort of money, but they are there, and someone must be buying the stupid things.

What possible effect 2 metres of flexible cable can have to counteract the kilometres of power company's wiring is a simple question to answer. None. Or, to more precise, none whatsoever. I am not referring to cables with inbuilt filters or other esoterica here, just perfectly ordinary mains leads.

I have measured the distortion on the mains at my workshop test bench. Last time I did this it was 5.6%, and there is absolutely nothing that a cable can do to change this, regardless of cost. The distortion is caused by a multitude of things completely outside our control, with power supplies for computers and other equipment being only one group of offenders.

These draw power at the peak of the AC waveform, causing it to become flattened (similar to clipping in a power amplifier). The various power company transformers along the way will also introduce some degree of distortion, and there are inductive and capacitive losses within the distribution system. As well, there are large motors being controlled by various speed controllers (most use large solid-state switches), used in industry and commercial centres. Lifts, air compressors, machinery, the list is endless.

Because of the resistance of the supply authority's cabling and transformers (there are some massive cost considerations they must address), when a high power appliance is turned on, the mains voltage falls. This resistance (actually it is impedance) will cause the voltage to vary from one second to the next, with significant drops at the times when meals are being prepared (electric stoves switched on all over the place), and at other periods. I have measured the impedance at my house at 0.8 Ohms (we use 240V in Australia), so an appliance that draws 10 Amps (such as a heater) will cause the voltage to fall by 8 Volts. This could be reduced by increasing the size of my internal wiring, but the gains would be few and the cost high. In 110V countries such as the US, the wiring impedance must be made lower, since all currents are higher for the same power. It is likely that this causes even greater compromise due to the larger wire sizes that must be used (larger wire means greater cost).

So, given that the mains is distorted, and varies in amplitude from minute to minute throughout the day, and has significant impedance, what can be done to fix this? One method would be to use an Uninterruptable Power Supply (UPS), which (if you get the right type) uses the incoming mains to charge batteries, then uses an inverter to supply power to your equipment. You can buy one of these for $3000, and the emerging mains supply will be as clean as the UPS can make it. No cable can do this, regardless of price.

Using a UPS will ensure that your 100W amplifier can provide 100W, despite the variations in the supply voltage. Whether you can hear any difference is doubtful, because even given that the mains can (and does) vary by up to 10%, your equipment should have a reserve power rating that can accommodate such variance.

I have been advised by a reader (in the US) who reminded me that unless the UPS is specifically designed for sinewave output (and the distortion is quoted), it will probably have greater distortion than the mains anyway. The voltage will be stable, but the switching noise of the USP may actually make matters worse.

A 100W amp (at nominal supply voltage) should give at least 100W. At 10% low supply, this drops to about 80W, a difference of less than 2dB. If you are operating power amps at close to clipping all the time, you will hear the difference, but this is not the way Hi-Fi gear is meant to be used.

> **Q:** Having a nice clean sinewave from the UPS or power conditioner should make a difference though, shouldn't it?
> **Q:** Why would it not make any difference to the sound from the amp?

The answers are simple and complex, but the result is the same. At the very best, transformer dissipation might be slightly lower, but the AC from the secondary of the transformer is rectified and filtered, making it into DC, since the amp cannot operate from AC power supplies. The amount of DC "ripple", or superimposed AC signal is determined by the design of the amplifier's power supply, and is completely independent of outside influences other than the mains supply impedance. Even this has a very minor effect in the greater scheme of things.

If I really wanted to be able to supply 100 Amps to my speakers for brief moments, my power supply can already do this. If I wanted to be able to do it all the time for extended periods, my speakers would catch on fire. No mains lead will give my power supply this ability, nor take it away. The limitations are in the supply itself, and include the transformer, rectifier and filter capacitors.

One useful observation is that the mains in the US seems to be basically pretty nasty, and not at all what we are used to in Australia. Interference seems to be a major problem, and if this is the case, it will find its way through the power supply and into the amplifier (or other equipment) if the power supply is not well designed.

Also, because of the lower mains voltage in the US (nominally 120V), the current drawn by power amplifiers in particular can cause real problems with cheap light duty cables. I have already made this point, but it is worth making again. Use of a heavy duty lead (possibly shielded if interference is a problem) will make a difference. Whether the power difference is audible or not is debatable, but elimination (or even reduction) of mains borne interference is likely to result in a worthwhile improvement in sound quality.

Normally I would expect that any interference would be audible all the time, and it seems very unlikely that it only manifests itself when there is music playing. Electricity is not that cunning, and is not by nature vindictive. Having said that, it must be noted that when an amplifier is producing a lot of power, the current spikes on the mains will be much greater, and may have an influence that would normally be un-noticed. The easy way to determine this is to move the leads about to find

out if this changes the background noise level. If it does, then re-locating the leads will provide far greater benefit than spending a king's ransom on power leads.

Use of a proper power conditioner (or a "pure" sinewave UPS) will completely eliminate mains interference, and this will naturally be beneficial. This is not something I have encountered, but if there is a problem, then this is probably the best way to fix it.

In some cases, all that may be needed is interference suppressors ("spike arrestors"), to get rid of clicks and pops that get into the system via the mains. These are readily available and fairly cheap, and might be a good place to start.

I have examined several mains leads I have, and upon inspection I saw that the pins of the US plugs are of thin sheet metal (brass). This is folded over for the flat pins (active and neutral) and rolled into a tube for the earth pin. In contrast, our plugs have solid brass pins, and are altogether much more substantial than the US ones (the US lead I have is rated at 13A, and is a very solid cable - but the pins are a weakness IMHO). The standard 13A fused UK plug is even more solid than ours - the pins are probably capable of at least 50A based on their size. One style of European style plug I have is also nice and solid. Elsewhere, I do not have samples, and can't comment.

To give you an idea. Listed below are the pin sizes and materials for 4 mains plugs I have

	Australia	10A	**US**	13A	**UK**	13A	**Europe**	10A - 15A
Active	6.4 x 1.5	Brass	6.2 x 1.1	F-Brass	6.3x 4	Brass	4.8 Dia	NP Brass
Neutral	6.4 x 1.5	Brass	6.2 x 1.1	F-Brass	6.3x 4	Brass	4.8 Dia	NP Brass
Earth	6.4 x 1.5	NP Brass	4.7 dia	T-Brass	8x 4	Brass	NA	

- F-Brass - Folded thin sheet brass
- T-Brass - Tubular thin sheet brass
- NP Brass - Nickel Plated Brass
- NA - Not Applicable (This connector uses a recessed socket, and has two plates for the earth contact, and a socket for the earth pin which is in the wall outlet)

As you can see, even though the US lead has a higher current rating and requirement, the pins are smaller and capable of less current. Where the others use solid brass pins, the US lead has thin sheet brass folded over to give a thicker overall pin - which is still thinner than the others. It is also wibbly - you can quite easily bend the flat pins with your fingers - I did ! Bent them right over at the base, *and* bent them in the middle. This is impossible with any of the others. From what

I recall of US wall outlets, they are also fairly wimpy affairs, with relatively poor contact surfaces.

Another point mentioned was that by using a high current shielded cable for the mains may prevent the current spikes caused by the amplifier's rectifier from injecting spurious noise into interconnects and other equipment. There may be some truth in this, and the effects are certainly measurable - this is why professional audio gear uses balanced connections, to eliminate exactly this sort of problem. Use proper "lead dress" - keep all power leads as far as possible from signal interconnects, and if they must cross, then cross them at right angles.

It also seems that the regulations in the US as to what you may (or may not) use as a power cable are somewhat lax (by Australian standards, anyway), allowing sub-standard connectors at both ends of the cable, and with seemingly minimal control over what may legally be sold as a mains lead.

Many (most?) of the high-end cables that I have seen referred to would not be legal in Australia, and in many other countries. No mains lead is allowed to be sold here without electrical authority approval - this is quite expensive to obtain, and involves voltage drop testing (the lead's resistance) and electrical insulation tests, along with various others. Shielded mains lead is uncommon, but I am sure that it would be available.

I have been taken to task seriously by some for not having tested any of the mains cables - well I can't, because I (like everyone else) have no criteria to base tests on. I know from experience that long (or light duty) leads will reduce the power available, but have no way to create interference of the type that could cause severe sonic degradation so I can verify that a cable eliminates it.

As to blanket claims that "the power cord has more influence than anything else in the chain other than room positioning of the speakers" (and yes, someone did make that claim), what can I say?

One of the respondents is apparently a distributor of high end power leads (so I discovered from someone else's posting), and he had no proof to offer, and nor did anyone else, so I am still left with the same conclusion as before (with some modification based on interference problems).

Other (Cheap) Things You Can Do

I had an e-mail from one of my regular readers, who was telling me that his apartment is wired using aulminium cable. This is (apparently) no longer acceptable in the US, but the fact that it was ever allowed at all is quite amazing. He discovered that he was having mains problems, so rather than "invest" in high-end power cables, he simply decided to replace the wall outlets with new ones, and re-terminate the aluminium house wiring. This in itself is not easy, because aluminium forms an oxide (*very* quickly) which is an insulator, and terminations need to be airtight - literally - to stop this from happening.

Aluminium also "flows" under pressure, so to terminate it properly needs a connector that applies constant pressure over a prolonged time - either that, or the terminations need to be tightened every couple of years. This can even happen with copper - many is the time I have found wall outlets where the connector screws were loose enough to allow the cable to move, this was not through negligence but simply the passage of time.

I quote (verbatim) from the e-mail -

> About the power lead, it's a sad world. Actually, my apartment has aluminum wiring. It is deemed fire-hazard these days, but it's an old building and they're not going to re-do the wiring. I had to replace three receptacles because the contact points of the aluminum wires slowly burnt away and left the sockets unusable. Whenever I plugged in a high-power equipment, it'd crackle, lose power and cause even more contact point to burn away.
>
> In that sense, buying a new $3 socket and getting it freshly connected to the mains wire helps HECK of a lot more than buying a $650 mains cable. As an added bonus, I get fresh copper socket holes. I'd think that helps a lot more than replacing a standard cable with a silver super-duper cable.

I couldn't agree more. This is a sensible approach, and does not cost a great deal. In addition, his apartment is (marginally!) less of a fire hazard than before, and the use of an expensive mains lead would not have fixed the underlying problem. Perhaps a few more people could adopt this sensible attitude and actually get some real (as opposed to imaginary or just "cover-up") improvements.

Bottom Line on Power Cables

I am still waiting for a "high-end" power lead manufacturer to supply me with some scientific proof of the advantages of their cable, and how they improve the sound. I have asked, and have not received the information. Nor do I expect to, since they cannot provide any sort of proof because they don't have any.

The last paragraphs of the above tell more of the truth of the matter than any high-end power lead maker ever will. The same (but to a lesser degree outside the US) benefits can be had from anyone who has old wiring and wall outlets regardless of where they live. Even in my own home, I have completely rewired the mains, because the old wiring had perished insulation, and all the sockets were worn out. The difference was not audible, but at least I know that an electrical fault is unlikely.

Speaker Leads

Speaker leads have been discussed extensively in my article on impedance, but I shall repeat some of this here for the sake of completeness. For the full text, see

Impedance [2] and Amp Sound, an article discussing the influences that affect the sound of amplifiers.

We hear so much about damping factor, the effect of speaker leads (and how much better this lead sounds
compared to an "ordinary" lead), and how amplifiers should have output impedances of micro-Ohms to prevent
"flabby" bass and so on. But what does it all really mean?

Before an informed judgement can be made, we need to look at some of the real factors involved. There are a
multitude of impedances involved in a typical amplifier to loudspeaker connection, most of them having a vastly
more profound effect than the impedance of the speaker lead alone.

For example, my own (tri-amped) hi-fi uses an amp for the bass and mid with a designed output impedance of about 2 Ohms. This provides a useful extension of the bottom end (I'm using sealed enclosures), without excessive peaking at resonance. Much the same effect is found with most valve amplifiers, which typically have an output impedance of 1 to 6 Ohms.

Ignoring the losses in the speaker lead (which are usually very small), the impedance of the cable is very low compared to that of loudspeaker crossover networks and the like. While there is no denying that some speaker leads do sound different, the important thing is "different" rather than "better"

A double-blind test carried out by an Australian electronics magazine many years ago found that most listeners thought that the really thin figure-8 type speaker cable had better bass than all the more expensive ones. Treble response was generally thought better using a heavy duty 3-core mains cable. No-one thought that any of the high priced cables sounded better than anything else.

Other workers in the field, such as Douglas Self [1], have determined much the same, so even in the light of some convincing evidence to the contrary, we have reviewers still extolling the virtues of cables costing more than a decent set of loudspeakers.

Generally, resistance and inductance in the speaker lead can (and does) cause minor variations in level, especially with difficult loads. These deviations are likely to be less than 0.1dB for reasonable cable constructions, with inductance less than 4uH. The resistance of a typical cable (perhaps 0.1 Ohm) causes response variations across the band, following the loudspeaker impedance curve, but these are usually even less at around 0.05 dB. Neither variation is audible.

You will even find references in some cases to the cable's characteristic impedance - a value that is only useful if cables are used for radio frequencies, or are many kilometres in length. These are uncommon in audio listening rooms in

my experience. The characteristic impedance of a cable has no effect whatsoever on signal frequencies that are low compared to cable length. At the worst (using coaxial cable) a signal travels at 0.8 of the speed of light (3x10^8 m/s).

Assume that for an adequate safety margin we want to be able to pass up to 100kHz through the speaker cable. The wavelength at this frequency is 3000 metres, or in coax, 3750 metres. A typical listening room may require up to 10 metres of cable, so at the very worst case, the cable is 1/300 to 1/375 times the wavelength of the signal. The effect is utterly insignificant in all respects. The signal will be delayed by an amount that is less than that experienced if the listener were to move his/her head by 1mm towards or away from the loudspeaker. This is of course a common occurrence, and often by several millimetres, even while asleep.

Difficult Loads

While it is true that twin cables (figure eight or zip cord) are adequate for nominal 8 ohm loads over short distances, there are a number of popular loudspeakers that are anything but nominal at high frequencies.

Two that a reader advised me about are the AR11 and the Quad ESL (old model). Both of these drop below 2 ohms in the treble frequencies. The AR bottoming out at 5kHz and the Quad at 18Khz (although anything from 15kHz to 18kHz is common). The dips are fairly sharp and so the load impedance is highly capacitive on the way down and inductive on the way up. The frequencies are high enough to not worry good amplifiers but what about the response at these dip frequencies?

Twin wire cables all have significant inductance which increases in proportion to length. With 10 amp rated twin flex over only 5 metres the response was down by 2.5 dB into one Quad ESL at 18 Khz, and 3.5 dB into the other speaker which had 8 metres. This was audible and unacceptable.

The only way to reduce cable linear inductance is to make the two wires talk to each other. Running in close parallel is a start, tight twisting is better but only by using multiple wires for each and interweaving can you really get the inductance down. Several cable makers have done this and sell them as low impedance cables, which is exactly what they are. There are several different cables that use this method, and twin coaxial cable is also used to achieve a similar result.

One construction uses two goups of 72 strands of enamelled wire plaited around a solid plastic core. Using these cables with difficult loads, the droop at either 5 or 18 kHz disappeared and the sound was distinctly better. There would be virtually no other way to solve the problem short of mono amplifiers sited next to each loudspeaker.

One (potentially major) drawback ocurs if you own certain amplifiers that are unstable with capacitive loads. Typical multiple twisted pair cable has about 9nF

per metre of capacitance with little resistance or inductance, which causes many amplifiers to go into parasitic oscillation. The fix is simple, wind twelve turns of wire around a pen and put it in series with the beginning of the cable. This tiny coil has far less inductance than even one metre of twin flex.

This description of the possible issues with speaker cables is the first I have seen that makes some sense from a technical perspective. Although I have not measured the linear inductance of standard twin flex, there is sufficient evidence from many writers that there are indeed some detectable (and measurable) differences. With this in mind, and wanting to provide all the information I can, I have included this information - and this is the one area where properly sized and well made cables really does make a difference. If you own speakers that present a highly capacitive load, or have deep "notches" in the impedance curve, I would take this information seriously.

Summary

Essentially, the main offenders in speaker leads are resistance and inductance. Of these, inductance is the hardest to minimise, and although usually small, it may still cause problems with some loads (see update, below). Many construction methods have been used, from multiple CAT-5 data cables, with the wires interconnected (usually all the coloured leads are deemed the +ve conductor, and all the white wires - the "mates" - are used as the negative). Because of the tight twist, the inductance is minimised, but at the expense of capacitance. In some cases, the capacitance may be high enough to cause instability in the amplifier, which not only does awful things to the sound, but can damage the amp.

Another popular method of minimising inductance is to use a pair of coaxial leads (e.g.75 Ohm TV/video coax or similar). The inner conductor of one and the outer conductor of the other are joined to make the +ve lead, and vice-versa for the negative. A good quality coax has a relatively low capacitance, and by interconnecting in this way, inductance is also reduced by a very worthwhile margin.

It is widely held that with difficult loudspeaker loads - as presented by many modern speaker systems with complex crossover networks - that reducing inductance can be very beneficial. This is especially true where the crossover causes significant drops in impedance at some frequencies. This also places unusually high demands on the amplifier - one of the reasons that some amplifiers just don't "cut it" with some speakers.

These problems can be reduced or even eliminated entirely by biamping or triamping [3], allowing the use of good quality but not extravagant speaker leads.

Resistance, which is easy to eliminate, reduces the damping factor and wastes power. With even reasonably robust leads, this should not be an issue

Bottom Line on Speaker Leads
Use quality cable, but extravagance will buy no more genuine performance. You will be able to obtain far greater benefits by biamping the system [3] than spending the same amount on esoteric (read "expensive") speaker leads.

Be willing to experiment, using 3-core mains cable (not the types described above, either), and paralleling two of the conductors for the speaker negative connection (or the positive - the speaker will not care either way). Save yourself a fortune, so you can buy more music instead.

I have seen several references on the web regarding the use of Cat-5 network cable and specially wired coaxial cable for speakers. The idea with network cable is to parallel the wires (these cables are usually 4-pair), and it is claimed that the sonic performance is excellent. I haven't tried it, but Cat-5 is relatively inexpensive, and might work quite well. Try it if you want to. Wiring coaxial cables for speaker use is also not too hard, and it is claimed that this can beat most of the really expensive cables.

Before one even considers the alleged benefits of one cable over another, here is something to think about ...

> "What does "veiled" mean (in reference to high frequency reproduction), and how is it determined that the veiling effect is caused by anything specific, as opposed to everything in general? This includes state of mind (i.e. good day, kids acting up, wife annoyed about something), health (cold or flu, hay fever), position of listening chair (was it moved to vacuum the floor?), etc."

And, no, these are not trivial questions. They are every bit as important as anything else, and all the more so if we have only a subjective interpretation of the sound, without measured results that show the effect. Have a look at the article "Amplifier Sound" for more info.

Interconnects

All well designed interconnects will sound the same. I said that at the outset, and will now explain this claim more fully.

The range (and the associated claims) of interconnects is enormous. We have cables available that are directional - the signal passes with less intrusion, impedance or modification in one direction versus the other. I find this curious, since an audio signal is AC, which means that electrons simply rush back and forth in sympathy with the applied signal. A directional device is a semiconductor, and will act as a rectifier, so if these claims are even a tiny bit correct, I certainly don't want any of them between my preamp and amp, because I don't want my audio rectified by a directional cable.

Oxygen free copper (or OFC) supposedly means that there is no oxygen and therefore no copper oxide (which is a rectifier) in the cable, forming a myriad of micro-diodes that affect sound quality. The use of OFC cable is therefore supposed to improve the sound.

Try as I might (and many others before me), I have never been able to measure any distortion in any wire or cable. Even a length of solder (an alloy of tin and lead) introduces no distortion, despite the resin flux in the centre (and I do realise that this has nothing to do with anything - I just thought I'd include it :-). How about fencing wire - no, no distortion there either. The concept of degradation caused by micro-diodes in metallic contacts has been bandied about for years, without a shred of evidence to support the claim that it is audible.

At most, a signal lead will have to carry a peak current of perhaps 200uA with a voltage of maybe 2V or so. With any lead, this current, combined with the lead's resistance, will never allow enough signal difference between conductors to allow the copper oxide rectifiers (assuming they exist at all) to conduct, so rectification cannot (and does not) happen.

What about frequency response? I have equipment that happily goes to several MHz, and at low power, no appreciable attenuation can be measured. Again, characteristic impedance has rated a mention, and just as with speaker cables it is utterly unimportant at audio frequencies. Preamps normally have a very low (typically about 100 Ohms) output impedance, and power amps will normally have an input impedance of 10k Ohms or more. Any cable is therefore mismatched, since it is not sensible (nor is it desirable) to match the impedance of the preamp, cable and power amp for audio frequencies.

At radio frequencies, Litz wire is often used to eliminate the skin effect. This occurs because of the tendency for RF to try to escape from the wire, so it concentrates on the outside (or skin) of the wire. The effect actually occurs as soon as the frequency is above DC, but becomes noticeable only at higher frequencies. Litz wire will not affect your hi-fi, unless you can hear signals above 100kHz or so (assuming of course that you can find music with harmonics that go that high, and a recording medium that will deliver them to you). Even then, the difference will be minimal.

In areas where there is significant electromagnetic pollution (interference), the use of esoteric cables may have an effect, since they will (if carefully designed) provide excellent shielding at very high radio frequencies. This does not affect the audio per se, but prevents unwanted signals from getting into the inputs or outputs of amps and preamps.

Cable capacitance can have a dramatic effect on sound quality, and more so if you have long interconnects. Generally speaking, most preamps will have no problem with small amounts of capacitance (less than 1nF is desirable and achievable).

With high output impedance equipment (such as valve preamps), cable capacitance becomes more of an issue.

For example, 1nF of cable capacitance with a preamp with an output impedance of 1k will be -3dB at 160kHz, which should be acceptable to most. Should the preamp have an output impedance of 10k, the -3dB frequency is now only 16kHz - this is unacceptable.

I tested a couple of cable samples, and (normalised to a 1 metre length) this is what I found

	Single Core	**Twin - One Lead**	**Twin- Both Leads**	**Twin - Between Leads**
Capacitance	77pF	191pF	377pF	92pF
Inductance	0.7uH	1.2uH	0.6uH	NT
Resistance	0.12 Ohm	0.38 Ohm	0.25 Ohm	NT

NT - Not Tested

These cables are representative of meduim quality general purpose shielded (co-axial) cables, of the type that you might use for making interconnects. The resistance and inductance may be considered negligible at audio frequencies, leaving capacitance as the dominant influence. The single core cable is obviously better in this respect, with only 77pF per metre. Even with a 10k output impedance, this will be 3dB down at 207kHz for a 1 metre length.

Even the highest inductance I measured (1.2uH) will introduce an additional 0.75 Ohm impedance at 100kHz - this may be completely ignored, as it is insignificant.

The only other thing that is important is that the cables are properly terminated so they don't become noisy, and that the shield is of good quality and provides complete protection from external interfering signals. Terminations will normally be either soldered or crimped, and either is fine as long as it is well made. For the constructor, soldering is usually better, since proper crimping tools are expensive.

The use of silver wire is a complete waste, since the only benefit of silver is its lower resistance. Since this will make a few micro-ohms difference for a typical 1m length, the difference in signal amplitude is immeasurably small with typical pre and power amp impedances. On the down side, silver tarnishes easily (especially in areas where there is hydrogen sulphide pollution in the atmosphere), and this can become an insulator if thick enough. I have heard of some audiophiles who don't like the sound of silver wire, and others who claim that solid conductors sound better than stranded. Make of this what you will :-D

The use of gold plated connectors is common, and provides one significant benefit - gold does not tarnish readily, and the connections are less likely to become noisy. Gold is also a better conductor that the nickel plating normally used on "standard" interconnects. The difference is negligible in sonic terms.

There is no reason at all to pay exorbitant amounts of hard earned cash for the "Audiophile" interconnects. These manufacturers are ripping people off, making outlandish claims as to how much better these cables will make your system sound - rubbish! Buy some good quality audio coaxial cable and connectors from your local electronics parts retailer, and make your own interconnects. Not only will you save a bundle, but they can be made to the exact length you want.

Using the cheap shielded figure-8 cable (which generally has terrible shields) is not recommended, because crosstalk is noticeably increased, especially at high frequencies. That notwithstanding, for a signal from an FM tuner even these cheapies will be fine (provided they manage to stay together - most of them fall to bits when used more than a few times), since the crosstalk in the tuner is already worse than the cable. With typical preamp and tuner combinations, you might get some interference using these cheap and nasty interconnects, but the frequency response exceeds anything that we can hear, and distortion is not measurable.

Digital / Optical Interconnects

Recently I have seen adverts and reviews on fibre optic digital interconnects. Some are supposedly far superior to others, despite the fact that 1s and 0s (light present, light not present) are all that is passed. IMHO, it would take truly monumental incompetence to design any digital interconnect that was incapable of passing a digital signal without corruption. Since fibre optics (non-audiophile grade) are used to carry phone calls and data all 'round the world, with very low error rates and over huge distances, it is ludicrous to assume that any commercial digital interconnect will make any difference over a distance of a metre or so.

Bear in mind that the receiver reconstitutes the signal wave shape, it is usually buffered, and will use some form of error correction as well. As for claims that the difference is audible ....

Summary

Aside from interference pickup, capacitance and crosstalk are the only real potential problem with interconnects. Capacitance can be minimised by selection of the cable. In come cases, even though the impedance of the preamp may be low enough, use of a higly capacitive cable may cause RF instability in the output stages - this will definitely ruin the sound.

Crosstalk is all but eliminated by the use of good quality shielding, which will generally also reduce interference. Keeping lead lengths to the minimum needed will also help reduce any possible negative influences.

Bottom Line on Interconnects
Use home made ones, or buy cables that are well made and reasonably priced. The expensive ones that will "make your system sound better" won't - you are just making some idiot richer, and yourself poorer.

I know that this is heresy to some, but I really don't care. This is factual, and I can prove my claims, while the makers of these fancy cables can't.

I have seen home-made cables, braided from multiple strands of wire-wrap wire. The shielding on some of these can be mediocre (at best), so experiment, but don't expect miracles.

Audiophile Capacitors

Here we have another bunch of lies - or perhaps half truths is a better description. There are differences between capacitors, but they are not (generally) audible - despite the claims. I have seen reference to dielectric losses, the "sound" of polyester is supposedly inferior to that of polystyrene, and on and on. The stupid part is that all these are true - at radio frequencies - at audible frequencies it is very hard or impossible to measure any difference (or hear a difference, using even a simple blind test).

At the frequencies you and I can hear, there is no audible or measurable difference between most capacitors, unless the equipment builder has done something monumentally idiotic, such as reverse bias an electrolytic. This is (fortunately) rare.

There are some capacitors that are inferior in some regards (but superior in others). For example, many ceramic capacitors have a temperature coefficient that causes the capacitance to vary with temperature (usually negative - N750 or N500 capacitors). NPO ceramic caps have a "negative/positive/zero" temperature coefficient - i.e. close to zero). There are dubious claims that these should not be used in audio, but they are useful in audio and RF designs for decoupling (bypassing). The values are generally too low to be useful in most audio circuits (although ceramics are made in higher values, but not always easy to get), but otherwise they would almost certainly be fine - after all, the dielectric is a ceramic and not plastic, so they have low loss and very low self inductance.

Many other high stability or low loss/high power RF circuits (but not those using inductors - N500 or N750 ceramics counteract the temperature coefficient of the coils) will use silvered mica or the like - this is great at 400MHz, but quite unnecessary at 20kHz. Mind you, they are far and away the best low value caps you can buy, and if you can tolerate the expense, fine. Just don't expect to hear a difference.

Many modern opamps have such a wide bandwidth that ceramic caps (usually in conjunction with electrolytics) should be the only choice for bypassing, despite the negative comments of some audiophiles.

Then there are electrolytic capacitors. Claim upon claim has been made about their distortion and poor frequency response, particularly at high frequencies. I recently saw an article (which I would give reference to if I could remember where I saw it) where a standard electrolytic and an audiophile grade unit were tested in the same circuit. The standard electrolytic was actually better, having a distortion component at mid and high frequencies that was only marginally worse than the "high end" unit, but was much better at low frequencies.

The audibility of an electrolytic cap is (to my mind) still highly contentious. At low frequencies, all electrolytics will start to introduce some distortion. The levels are quite low, but as the capacitor's reactance becomes significant, distortion rises.

The reactance of any capacitor is determined with the formula

$$X_c = 1 / (2 * \pi * f * C)$$

where X_c is capacitance reactance, f is frequency and C is capacitance (in Farads)

If Xc is maintained at 1/10 (or 0.1) of the supplied load impedance, then this low frequency distortion will not be an issue, but in any case is far lower than that of a loudspeaker.

High frequency performance is affected by the capacitor's internal inductance and dielectric losses, which causes a rise in impedance as frequency increases. It is very common to see electrolytics bypassed with polyester or similar caps, and for RF this is essential. It is also needed when bypassing the power supply rails of an amp, since at the frequencies that amps like to oscillate at (typically above 1MHz), the electrolytic simply has too much impedance. For audio frequencies a bypass is not needed, but will do no harm.

The combined effects of internal resistance and inductance contribute to the electrolytics' equivalent series resistance, or ESR. This can be measured (I have an ESR tester), and is a good indication that a cap is failing. As electrolytics age, their ESR will rise until a point is reached where the component will be unserviceable.

As a test, I checked a few caps in my workshop. I could not measure any distortion created by an electrolytic passing signal current (as opposed to speaker current, which I did not test at this stage). I also checked the frequency response of a couple of electros, and found zero degradation at 100kHz - even a square wave was passed with no visible deterioriation in rise time (which would indicate frequency limitation).

I then tested the ESR and capacitance of a 220uF and 10uF electrolytic, and a 1uF polyester capacitor.

Type	Value	Meas Val.	ESR
Electro	220uF	207uF	0.17
Electro	10uF	10.1 uF	1.2
Polyester	1.0uF	1.02uF	1.5

I thought that this was quite interesting, personally. If we use 10uF electros where we might have otherwise used a 1uF polyester, the ESR is better. Will it make any difference whatsoever to the sound? Of course not. None of these devices introduced any measurable distortion or anything else that I could see. One thing I know for sure is that if I can't see any change on my distortion meter residual, then there is no change. A complex waveform does not affect the validity of this testing, since I can test distortion at any frequency I like, and the appearance of multiple frequencies at once does not affect any passive device.

Considering that I use the averaging facility on my oscilloscope to eliminate noise completely, I can see the most minute change in a signal waveform. If nothing can be seen here, then no-one, regardless of how good they think their ears are, will be able to hear the difference in a properly conducted test.

I was recently taken to task for not mentioning tantalum capacitors. I hate them! They are unreliable, and many tests have shown that their linearity is highly suspect. The only intermittent short circuit I have ever found in a cap was with a tantalum in a power supply circuit. It would fail for long enough to blow the fuse, and then work again. I strongly suggest that you don't use tantalum caps in anything more advanced than a dustbin.

Bottom Line on Capacitors

Various people have advocated passing pulse signals through two different sorts of capacitor, and subtracting the result, claiming that the non-zero residue proves that capacitors can introduce audible errors. In fact such tests expose only well-known capacitor shortcomings such as dielectric absorption and series resistance, and perhaps the vulnerability of the dielectric film in electrolytics to reverse biasing.

No-one has been able to show how these imperfections could cause capacitor audibility in an amplifier,and my own tests confirm this.

I must confess though, that perhaps we don't know how to perform the "audibility" tests. I do not believe that there is a significant difference, but many do ... who knows?

Non-polarised electrolytics are a different matter, especially when used in crossover networks. These have a tendency to lose capacitance as they age, shifting the crossover frequency with disasterous results (sonically speaking). Because the loss is gradual, you may possibly not even hear it until the tweeter has almost stopped working, as you get used to the sound over a period of time. Unless all bi-polars age at the same rate (unlikely), you *will* start to notice a difference between the two speakers. This is your cue to head off to the electronics shop and buy some replacements (non electrolytic, preferably). There are (supposedly) some major audible differences between bipolar electrolytics and film dielectric (plastic) types. This is your chance to test the theory.

A reader wrote telling me I was wrong about capacitors, and that the differences are audible. The specifics of this audibility were not discussed, and no measurements were offered, except for the following observation:

> There is an audible and measurable difference between different dielectrics. It's less to do with dissipation factor, and more to do with dielectric absorption. There is no black magic about it - its very well documented throughout the entire range of electronics industries. Here's how to convince yourself that this is possibly the most insidious source of distortion in audio. Get a largish value electrolytic reservoir cap and charge it up to (say) 50 volts for a minute or so. Then, with a DVM attached to the terminals, discharge the cap so the voltage reads zero.
>
> After removing the discharge resistor, watch the voltmeter reading climb back up as the cap miraculously charges itself back up from nowhere. In a signal coupling capacitor this would be bizarre enough behaviour to be a worry, but can you imagine what the effect must be if the cap is in a feedback loop? Give it some thought, and think about how much damage would have to be done to a signal to loose the ambience surrounding a quiet instrument buried in a large ensemble. Think of reverb at -60dB, or lower.
>
> Dielectric absorption is significant, and ceramic caps suffer from it badly, as do electrolytics. Do some measuring, but more importantly, do some listening.

Fair comment, and it deserves an answer. I also know the "stored charge" phenomenon of electrolytics (I actually demonstrated it to my son recently), and although this is absolutely real, it does not reflect the behaviour of the cap in a real world amplifier.

Most capacitors normally don't charge and discharge in this manner, but remain charged to some DC potential at all times. The charge recovery mechanism should never come into play in a properly designed circuit, regardless of programme material. There are exceptions! A capacitor used as the "dominant pole" or Miller capacitance in the Class-A amplifier section of a power amp is charged and discharged fully with each cycle of the input waveform. Ceramic capacitors are commonly used in this role, but I suggest that polystyrene is probably much better. Will you be able to hear the difference? My own experience

is that you should not hear the slightest change in the sound, but it is conceivable that with some amplifiers this may in fact be audible in extreme cases.

The dielectric absorbtion process is present to some degree in all capacitors, and although some are definitely worse than others in this respect, I have conducted some tests with my Sound Impairment Monitor (SIM), which has never been able to detect any degradation of the type you might think should happen.

The claim that there will be an effect similar to reverberation at -60dB is complete nonsense. No such effect is measurable or audible. I do think that after all these years, someone would have worked out a way to prove this effect if it existed at all. No such proof has been offered, but I have seen "proof" that a ceramic capacitor (pushed way beyond its voltage rating if I recall correctly) can introduce some measurable distortion. The solution is easy - don't run any capacitor at above its voltage rating, and all will be well.

Feel free to test the theory. Make sure there is no DC in the signal line, and connect a bipolar cap (say 10uF) in series with the interconnect between preamp and power amp. Wire a switch across the cap, and have someone operate the switch while you are listening. You have to be able to hear a difference at least 75% of the time (and accurately identify whether the cap is in or out of circuit). If you can do this, then the probability is that the capacitor is audible (unless you do something nasty with the switch wiring that gives audible clues - this is cheating :-)

High Current Amplifiers

There are some who insist that the instantaneous current output needs to infinite (or at worst, half this value), and that amplifiers with limited current sound terrible. This is another piece of nonsense.

Let's assume that a nominal 8 Ohm loudspeaker load has an impedance minimum of 1 Ohm at some frequency. This is a bad design, but a valid assumption. This means that the amplifier must be able to supply a maximum of 8 times the normal current. A 100W amplifier would then supply a normal peak current of a little over 3.5 Amps. At the frequency where impedance falls to 1 Ohm, this becomes just over 28A.

So let's have a look at the very worst case possible, where the load is fully reactive and returns all supplied energy 180 degrees out of phase (at this point, the load is performing no work, so if a loudspeaker, is making no sound). The amplifier now has to deal with two lots of current - that supplied to the load, and that returned from the load. Even it it were possible, the worst case above would require a current capacity of 56A, however a loudspeaker that presented such a load to any amplifier will not last long in the market, since it will blow up nearly every amplifier that is attached to it.

There is no audible benefit whatsoever in creating an amp that can supply 100 or 200A, since the load will never need this current and is incapable under any circumstance of drawing more than the applied voltage and minimum impedance will allow (allowing for the reactive component of the load).

Bottom Line on High Current Amps
Most quality amps will be able to supply sufficient current to drive the loudspeaker load. Any more capability than this is a waste of money, since it will never be used. To achieve these extravagant currents, the output stage and power supply must be far larger than will ever be needed in real life.

Class-A amplifiers are generally capable of a very modest current, usually barely above that theoretically needed to drive the speaker. I have not heard anyone claim they are rubbish, because of the low current capability.

The one exception is with extreme crossover networks or other speaker configurations that create a difficult impedance load. It will often be found that some amplifiers cannot drive these speakers well, and others have no problem. An amplifier capable of high current may sound better with these loads, but I suggest that the speaker design is flawed if the designer is incapable of creating a crossover that cannot maintain a respectable impedance.

Monoblock Power Amps (And Preamps)

Someone has managed to convince a sizable segment of the audiophile fraternity that to achieve acceptable channel separation, completely separate amplifiers must be used. Considering that it has been shown [5] that 20dB channel separation is quite sufficient for a full stereo image to be appreciated, it is nonsense to claim that infinite separation is needed or desirable.

It is not at all difficult to design an amplifier with better than 50dB separation, even using valves, and any more than this is of no audible benefit. The "cross-modulation" effect that a shared power supply supposedly introduces is drivel. If an amp is so heroically ill-conceived as to suffer from cross-modulation, then simply sticking it into its own case with a separate power supply certainly won't fix it. I might suggest that it is most ideally suited as a boat anchor, since the design is so seriously flawed that it is beyond salvation.

A common power supply is a sensible (and far cheaper) alternative, and will cause no crosstalk in itself. Most amps have a very high ripple rejection, and if they reject ripple, they will also reject any signal frequencies that happen to get onto the supply line.

In fact, the conventional power supply capacitors will filter out all but the lowest frequencies anyway, and since bass is almost invariably recorded onto disc as

mono, a minor amount of crosstalk at low frequencies is of no consequence - even if it *were* possible by this means, which it generally is not.

Bottom Line on Monoblocks

Unless you only need a single channel amp (for a subwoofer, for example), they are a waste of money, and serve no useful purpose. You will get a slight improvement in output power, but the real difference will be inaudible in the majority of cases.

Alternatively, they are useful if you want to have the shortest possible speaker leads. The amp can be installed next to the speaker, and a very short lead used to connect the two. Then we create a problem with the low level interconnects, which will be of significant length. There is far more chance of interference and high frequency loss in long interconnects than in speaker cables, so ideally the interconnects should be low impedance balanced circuits. Sadly, most monoblocks do not offer this essential option.

Power Supplies

I have seen reviews, and claims by amplifier designers, that for this amp to sound good, it must have a fast power supply. A power supply does not have speed - high, low or otherwise ... unless it is regulated.

> **Anecdote:** A regulated supply will have a finite ability to maintain its output voltage as the load varies - this is well known in engineering circles, and can cause problems if it is not fast enough.
>
> I have worked on power supplies (many years ago) that were used to power the head positioning amplifiers in the old washing machine sized computer disk drives. One of the tests that we needed to run was a switched load - varying the load from about 0.1 of the rated current to full current repeatedly.
>
> Detectors were used to measure how far the output voltage dropped when the full load was applied, and I designed the circuit to do this. It was fairly fast, and would latch a "Fail" LED if the output fell below a predetermined limit for more than about 1us. BTW, the low voltage limit was set at only about 1V below the rated output voltage, which was 24V if I remember correctly.

So, speed is valid for a regulated supply for a critical application, but is completely meaningless for a power amplifier with an unregulated supply - which is 99.9% of them. There is no audio signal that is so fast that it will demand power from perfectly ordinary electrolytic capacitors faster than they can supply it. It is not necessary (other than for radio frequency bypassing) to use polyester caps in

parallel with the main electrolytic filter caps, and nor is there any valid reason to specify that 100,000uF (or any other outlandishly expensive number) is needed to power an amp so the supply will be "fast".

A standard electrolytic (say, 10,000uF) will have an equivalent series resistance (ESR) of perhaps 0.01 Ohm, which means that it has an internal time constant of about 100us. More significant is the fact that discharge current is limited by ESR, so if charged to 50V, the maximum current available is 5,000A peak - this is a lot of current! In fact it is so high that it can destroy the cap itself - this is a very good reason not to use a screwdriver to discharge a power supply, well apart from the fact that a decent amount of capacitance will take the end off a small screwdriver.

If this 50V supply is connected to a 8 Ohm speaker via an amplifier, the maximum current the speaker will draw is 6.25A (although some speakers will demand more at certain frequencies). In reality it will be far less than this most of the time. I can make a power supply "slow", simply by placing some resistance in series - the caps will no longer be able to discharge at their maximum rate. Will this affect an amplifier? Only in that the maximum power will no longer be achieved, but this will also happen if the AC mains supply is 10% low. Does this somehow degrade the sound of an amplifier? I think not.

Bottom Line on Power Supplies

Fast power supplies are a myth, as all power supplies are inherently "fast" in this context. Regulated supplies are generally only used with Class-A amps to reduce ripple. These do not have to be fast, because the current variations are much lower with the Class-A topology. Most will have a fair sized electrolytic at the regulator output anyway, so they are "fast" again.

Massive capacitance and "audiophile" grade caps are not going to improve the sound of the DC from your supply, regardless of cost or claim. The power supply is a passive part of the amplifier, and has little or no influence on the sound, unless grossly and ingeniously poorly designed. I say "ingeniously", because it would take spectacular incompetence to so badly design a power supply that it audibly affected the sound at any signal level below clipping. From some of the posings I have seen on various bulletin boards, such incompetance may well be rife, since just changing a power lead makes them audibly better :-)

"Special" Designs

The editorial page has a pair of prime examples of "Special Designs", including a more detailed examination of the sample below. See I am as Mad as Hell for more info.

I recently saw information on the web about an amp whose claims to fame (infamy, more like it) were along the following lines (this is taken from the site)

- World's smallest number of parts - 9 parts per channel (excluding attenuators)
- World's shortest signal pass length - 32 m/m (including the length of parts)
- World's shortest NFB loop length - 9 m/m (including the length of the resistor)
- World's smallest filter/condenser - 1000µF
- Powerful voltage regulation with high capacity transformer - 170 VA cut-core transformer +- individual coils
- Dual mono construction with each channel in a separate chassis.
- Rigid and compact aluminum chassis construction to release vibrations smoothly.
- Separate 12-position attenuators for each channel.
- Can be up-graded into a pair of complete mono amplifiers by adding another Model X Stupid Name

Oh, wow, and ... I mean ... like ... who gives a toss! This amplifier sold for some astronomical sum, and as near as I could tell from the advertising blurb, seems to use a couple of power opamps as the entire circuit. The power supply was separate.

So the amp has few components and a short signal path. What about the several hundred metres of standard professional class cable and very long signal paths that are common in the mixers that were used in the recording studio? Is this "magical" short signal path going to somehow make that all go away - somehow I doubt it. Since this amp does use a power opamp, the manufacturer obviously does not count the 30 or so transistors inside the device - why not? They are real, whether you acknowledge them or not.

As for the "world's shortest negative feedback path". So what? The claim was made that by doing this, power supply bypass capacitors that by some mystical process ruin the sound were not needed. What rubbish. My 60W power amp has a negative feedback path that is about 50mm long - in other words, typical. Because of its design, it will operate perfectly happily with no power supply bypass capacitors too - the result is greatly reduced power because of the resistance of the power leads. Do you want that? Does this sound like a good idea? No, I didn't think so either.

The one I liked best (or least, depending on how you think I read this nonsense) was the "world's smallest filter capacitors". What possible benefit - other than profit maximisation - does this infer? I honestly have no idea. I could run my amp with 1000uF caps too. Anyone can. The immediate result is a dramatic reduction in power, as ripple voltage is very high at any reasonable power level, and you start to get clipping as the ripple voltage encroaches on the audio signal. Ah, but we also have "powerful voltage regulation" and a high capacity transformer. Big deal. I can run my amp off a 10kVA transformer if I want to, and it won't change the sound one iota. Anyone can make a voltage regulator (assuming that one is actually used, which I doubt), but why? Extra heatsinks, more stuff to fail, and zero sonic benefit.

I won't even bother discussing the "dual mono construction", but I am intrigued by the "rigid and compact aluminium chassis to release vibrations smoothly". Quite

apart from the fact that being rigid and compact in no way ensures that vibrations will be released smoothly or otherwise, I am at a complete loss as to why anyone might think for an instant that this was important. This is an amplifier, not a speaker cabinet. Left to their own devices, amplifiers don't normally vibrate - this is not one of their characteristics. Are we supposed to believe that a power amp is in some way microphonic?

Try this (if you dare). Place your ear as close as possible to the speaker, and have someone drop the power amp a short distance while powered on and connected. What do you think is the chance that you will hear anything from the speaker (other than if the amp destroys itself when it is dropped)? I will tell you, to save the embarassment of having to explain to the service guy what happened to the amp. Nothing, that's what. If these clowns *have* managed to make an amp that is microphonic, then I definitely don't want one.

Bottom Line on Special Designs
Most are rubbish, but genuinely overpriced, while others are just trying to do something different (which they're not) and desperately attempting to convince (confuse?) us that it makes a difference. It doesn't.

I thought about this one for a while, and it finally made it into my "Hall of Infamy" - the editorial. You can read more about it there (see above).

Opamps

Many is the claim that opamps have a distinctive sound, and can readily be heard in audio equipment. Discrete designs supposedly sound superior, regardless of the fact that in many cases they will measure worse than even a cheap opamp.

I have never been able to measure an opamp's distortion, because it is so far below my equipment's limits that it cannot be detected. Devices are available with distortion as low as 0.00008% - this is close as you can get to the ideal "straight wire with gain". The bandwidth of the better devices is so wide that significant gain is available at 100kHz, so phase irregularities and response problems are non-existent in sensible designs.

Considering the fact (and in the vast majority of cases, it is fact) that the final mixed down signal you get from a CD has passed through up to 100 opamps at various stages of production before you even get to listen to it, it is ludicrous to assume that *not* using opamps in the last 1% of the audio chain will have any audible effect.

Bottom Line on Opamps
Opamps are great. They simplify design, have low distortion and excellent power supply rejection, and good ones are very quiet indeed. There are few areas where a discrete design will be better. This naturally assumes the use of good quality

units - the venerable uA741 might be OK in a thermal controller, but you don't want them in audio gear (although you might be surprised at some of the opamps that you might find - some are little better than the 741, but they are still used).

Valves (Tubes)

Valve amplifiers are back, with units in all sorts of configurations selling for astounding sums.

The valve sound is one phenomenon that is real. It has been known for a long time that listeners sometimes
prefer to have a certain amount of second-harmonic distortion added in, and most valve amplifiers provide just that, due to huge difficulties in providing good linearity with modest feedback factors.

While this may well sound nice, hi-fi is supposedly about accuracy, and if the sound is to be modified in this manner, it should be set from the preamp front panel by a control (Douglas Self suggests a 'niceness' knob).

Valves offer some advantages - their overload characteristics are smoother than solid state designs, so even when clipping the sound is less harsh. While this is most desirable for a guitar amplifier that will be operating into clipping for much of the time, it is unhelpful for hi-fi, where clipping should be avoided altogether.

Valve amps also have much higher output impedance than transistor amps, and this makes some speakers sound better. It also makes other speaker sound worse, so the results are unpredictable.

There are few modern transistor amps that will measure worse than any valve amp, regardless of cost. Indeed, the vast majority are so superior in all respects that it is difficult to justify using valves in anything other than guitar amps, where, despite much advertising hype, no transistor amp has ever been able to sound exactly the same as a valve unit. Close - but not the same.

The rash of single-ended directly heated triode monoblock amplifiers of late is something that astonishes me. These will typically have a distortion of 1 to 3%, are of low power - typically less than 10W, and have no redeeming features (IMHO).

Such an amplifier generates large amounts of second-harmonic distortion, due to the asymmetry of
single-ended operation, and needs a very large output transformer because the primary carries the full DC anode current, and core saturation must be avoided. The inherent distortion of an iron cored inductor or transformer is ever-present, and only global feedback can remove it.

High values of feedback around a transformer are extremely difficult, because the phase irregularities generally cause the amplifier to oscillate. This may have been the state of the art 50 years ago, but there is no sensible reason to go back. Next we will hear someone extolling the virtues of the wax cylinder as having superior sonics to vinyl or CD (needless to say these superior sonics will be "very subtle" and "only audible with the finest (i.e. most expensive) single ended triode monoblock amplifier").

In one review, a single ended triode amplifier yielded 3% THD at 9 Watts, at a cost of $3400 [4]. This is an appalling result for a very expensive single channel amp. The amplifiers in powered computer speakers are better than that!

Despite all of the above, I have no doubt that many of these amps sound delightful. Not exactly my cup of tea, but having used valve amps of many types over the years (including those I designed and built myself), I still like the sound of them. They also don't blow up with difficult loads - they may stress out a little and give less power than normal, but they survive. The majority of valve amps are far less forgiving of open circuits (no speakers connected), and some will fail if pushed hard into an open circuit. The typical failure mode is a high voltage flashover, which either carbonises the valve socket or base (or both), or causes the insulation in the output transformer to fail.

Bottom Line on Valves

This is one area I shall leave open-ended. There are some valve amps that do sound very good indeed, but are generally very expensive. Valves are also fragile, generate copious amounts of heat, and have a limited life. Correct biasing is essential, and few valve amps provide a simple method of doing this.

The trend towards having these hot "bottles" out in full view, and able to be touched (and / or broken) by age challenged persons (the rug-rats) is a definite safety hazard. I would not like anyone's kids to be able to burn and then electrocute themselves in one small mishap.

.... However - I do use a valve preamp in my own system, and I have no idea what that says about me. It does sound nice, but I am probably deluding myself in thinking that it is better than my solid-state preamp. That's fine for me, because I designed and built it, so it didn't cost me a king's ransom.

Speakers

There are many very fine loudspeakers available, and interestingly, although these have a far greater effect on the sound that you hear than the amplifier, there is nowhere near the controversy with loudspeakers as seems to be evident with the rest of the audio chain.

Certainly there are proponents of various crossover alignments, the benefits or otherwise of vented boxes versus sealed, but otherwise this seems to be a reasonably sensible (even if intimidatingly expensive) field of endeavour.

Most audiophiles have their favourite speaker system(s), and these will all have some undesirable characteristics, for such is the state of the art. The perfect loudspeaker does not exist, because of the physics of making electro-mechanical objects with finite mass react in a completely predictable manner at all frequencies. This (of course) is something that speakers cannot do.

A flat frequency response is desirable, and rapid decay of internal resonances means that the loudspeaker contributes a minimum of its own sound to that from the source. Good quality drivers and well braced, non resonant cabinets, combined with high quality components in crossover networks and a sensible approach to ensure that phase irregularities at the crossover frequencies do not cause response or impedance peaks and dips are common in most quality systems.

The listening room and the recorded material has a very great influence on the final sound you hear, vastly more than a few interconnects or a mains lead. No-one is going to make the listening room anechoic, and nor would you want to. The positioning of speakers is one thing that can have a profound effect on the sound, but this is so often completely ignored.

One problem is that the optimum placement of speakers for sound quality will often be completely inappropriate to the layout of the room, meaning that a liveable area is no longer available, and causing much friction between the listener and s/he who must be obeyed.

Bottom Line on Speakers

Buy what sounds good, build your own and experiment, whatever. This is too complex an area to try to offer suggestions or advice (although there are many who will do just that, with no knowledge of your listening room, its furnishings or anything else).

Bear in mind that building a speaker system without measurements is futile. The ear (and attached brain) is easily fooled, and has a very short memory for what you hear. Speakers can have huge anomalies in response, and within a few minutes the brain has made the necessary adjustments, and everything will seem to sound as it should.

Try this experiment. If you have a graphic or parametric equaliser, reduce a band somewhere in the midrange area (say, between 500Hz and 1kHz). Listen to the system for about 15 minutes, then restore the missing frequency range. Suddenly, the system will sound as if it has a hugh peak in the midrange, and for a time will sound awful. Within another 15 minutes or so, everything will have settled back to normal.

Conclusion

The subjectivist approach will cost you a lot of money, and possibly yield a system that is less hi-fi than something from a department store. A review without technical tests is without substance or meaning, and nearly all descriptions about amplifier sound should be taken with a large dose of salt (possibly epsom).

Claims that power leads and interconnects will magically transform the sound of your system are false and misleading in the extreme. The various system components may be influenced by some combinations, but a well designed system should not care.

The current impasse between the scientific and subjectivist camps is unlikely to be resolved in the near future, because as politics and religion have shown over the centuries, people will believe what they want to, despite any evidence that may be offered to show that they are misguided or just plain wrong.

There is great difficulty defining the quality of an audio experience - you can't draw a picture to show what something sounded like. In addition, our acoustical memory is more fleeting than visual memory. It is much easier to visualise what the Sydney Harbour Bridge looks like than to recall all but the basic details of a musical performance.

> From Douglas Self -
> It has been universally recognised for many years in experimental psychology, particularly in experiments about perception, that people tend to perceive what they want to perceive. This is often called the 'experimenter expectancy' effect; it is more subtle and insidious than it sounds, and the history of science is littered with the wrecked careers of those who failed to guard against it. Such self-deception has most often occurred in fields like biology, where although the raw data may be numerical, there is no real mathematical theory to check it against.
>
> When the only 'results' are vague subjective impressions, the danger is clearly much greater, no matter how absolute the integrity of the experimenter. Thus in psychological work great care is necessary in the use of impartial observers, double-blind techniques, and rigorous statistical tests for significance. The vast majority of Subjectivist writings wholly ignore these precautions, with predictable results. In a few cases properly controlled listening tests been done, and at the time of writing all have resulted in different amplifiers sounding indistinguishable. I believe the conclusion is inescapable that experimenter expectancy has played a dominant role in the growth of Subjectivism.
>
> It is notable that in Subjectivist audio the 'correct' answer is always the more expensive or inconvenient one. Electronics is rarely as simple as that. A major improvement is more likely to be linked with a new circuit topology or new type of semiconductor, than with mindlessly specifying more expensive components of the same type; cars do not go faster with platinum pistons.

All the above notwithstanding, most audio designers will still tend to accept (however reluctantly) some of the subjectivist propaganda, if only to be able to extract some of the obviously serious money that would otherwise go elsewhere. There is nothing wrong with this in principle, but where this happens, you will almost invariably get what you pay for, and the equipment's performance will be (hopefully) satisfying to both camps.

Just as likely is that the subjectivists will determine that this same piece of equipment is hopelessly inadequate in all respects, despite the fact that it has zero distortion of any kind, and a frequency response from DC to daylight. (A good quality standard interconnect comes to mind!)

Further Reading

For further reading, have a look at "Amplifier Sound", a new article that tries to rationalise some of the misunderstandings and differences of opinion that abound in the audio field.

The articles listed in the References are an additional source for information on these topics.

References

1. Wireless World, July 1988 - D. Self 'Science and Subjectivism in Audio' (See also The Self Site)
2. The Audio Pages, ESP, Impedance
3. The Audio Pages, ESP, Bi-amplification - Not Quite Magic (But Close)
4. Stereophile, Sept 1995 - R. Harley 'Review of Cary CAD-300SEI Single-Ended Triode Amplifier'
5. BBC Engineering Monograph No 52 - 'Stereophony & The effect of crosstalk between left and right channels'