The Wire and Cable Scene: Facts, Fictions, and Frauds Part II

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Here we come to the technical examination of the subject, as announced in the last issue. This part deals with the amplifier/speaker interface and the effects of wires/cables at that junction in the system.

I wouldn't be entirely forthright if I didn't state right up front that this article is, in a sense, quite unnecessary. In the August 1989 issue of *Audio,* Richard A. Greiner, Ph.D., professor of electrical and computer engineering at the University of Wisconsin, published an article under the title of "Cables and the Amp/Speaker Interface," which in turn was an updated adaptation of his original paper, "Amplifier-Loudspeaker Interfacing," published in the May 1980 issue of the *Journal of the Audio Engineering Society* and presented a year earlier at the AES convention in Los Angeles. Everything of substance I'm about to say on the subject of speaker cables has already been explained—100% correctly, lucidly, and in great detail—by Professor Greiner; I can only add my own little flourishes, commentary, and illustrations. For some perverse reason, the rank and file of audio consumers will give credence to the most ignorant exudations of gonzo audio journalists and loudmouthed dealers while tending to regard with suspicion and skepticism a superbly accredited and commercially disinterested authority like Dick Greiner. I was disgusted by some of the reactions to the *Audio* article, and I offer what follows here in the faint hope that I can tip the scales back—even if only part of the way—to sanity.

(By the way, as some readers may still remember, I had a little tiff with the professor a good many years ago, in my "Letters to the Editor" column. I overreacted in a needlessly intemperate manner to a mild bit of professorial pomposity, which at the time I perceived as condescension, and he took offense. Actually, I have the greatest respect for the man and wish in retrospect that the contretemps had never taken place.)

What cable cultists never think about.

For openers, let's face a few simple facts of life. Such as:

Inside a large and complicated loudspeaker system there may be as much wire, or more wire, than between the amplifier and the speaker terminals. It starts with the voice coils (a single turn of one those 4-inch JBL voice coils is over a foot long—and how many of those turns are there?) and continues with all the wires connecting the individual drivers to the crossover network, the wiring inside the crossover network (including large coils), and then the wiring from the crossover to the outside terminals. Or take the Quad ESL-63, a particularly poignant example, with the staggering length of thin, nontweako wire in its unique delay line. Then, of course, there's also a significant length of wiring inside the amplifier before the output is brought out to the terminals. In the case of tube amplifiers, add to that the great length of wire in the output transformer. The cable cultist has absolutely no control over the dimensions, geometry, or metallurgy of these hidden wires and cables—even if such dimensions, geometry, or metallurgy were of serious sonic importance. It's like being a health-food faddist at lunch but not at breakfast or dinner. Thus, before any discussion of engineering considerations, irrationality raises its bony head. (Or did you think Celestion wires the inside of the SL700 speaker with MIT Music Hose?)

Another fact that needs to be faced from the start is that music, or any other audible program material, consists of frequencies from about 15 or 16 Hz to 21 or 22 kHz. (I'm being very generous and therefore assume state-of-the-art recording and 16-year old hearing prodigies.) Let's expand that bandwidth to 50 kHz, however, since it doesn't cost us anything in an abstract argument and will make bandwidth fetishists happier. Surely, no information above 50 kHz needs to be transmitted by the amplifier to the speaker. Is a speaker cable's performance above 50 kHz relevant then? Does it have to be a good microwave transmission cable? You know the answer, but keep it in mind as we examine the network characteristics of speaker cables.

Let's also agree, before we proceed, that a direct connection from the amplifier output terminals to the speaker input terminals—perhaps with an inch or two of bus bar or braid but without any cable as such—is the theoretical ideal and that nothing can be more accurate than that. Ask a cable cultist what's better than pure silver cable, or any other cable, and he'll be most unlikely to give you the obvious answer, which is also the scientifically correct answer: no cable at all. That will be our standard of perfection for the purposes of this study.

Modeling the amplifier/speaker interface.

This is where my small contribution comes in—my doodles, as it were, on the margins of the Greiner articles. I claim absolutely no originality here; all of what I'm doing is quite straightforward and ordinary; however, I haven't so far seen the real-world effects of speaker cables illustrated in exactly this manner anywhere else.

As Dr. Greiner points out, the amplifier/cable/speaker interface can be represented by the lumped-element equivalent circuit shown in Figure 1. This is a sufficiently accurate representation for our purposes; treating the cable as a transmission line is theoretically "purer" but a total waste of time, considering even the longest cable runs and highest frequencies encountered in audio work. (Did I say 50 kHz? That's a wavelength of 6 kilometers!) Thus, a length of cable between

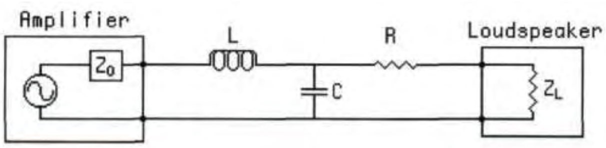

Figure 1: Equivalent circuit for the amplifier/cable/loudspeaker interface, with lumped circuit elements.

the amplifier and the speaker is, electrically speaking, a series inductance, a shunt capacitance, and a series resistance. That's all it is, really, unless you get involved in second-order and third-order effects that have no influence on the transmission of audio frequencies over domestic distances, e.g., skin effect, which is also called radio-frequency resistance (although the high-end audio cable touts would rather die than refer to it by that self-stultifying name). Once you have characterized a speaker cable as an RLC circuit, you can predict with considerable precision its effect on the network which it forms with the source (viz., the amplifier) and the load (viz., the loudspeaker).

Luckily for me, Martin Colloms (the noted Jekyll-and-Hyde audio journalist in England, who does excellent technical work but talks audio-salon voodoo) has already measured the RLC values of 44 name-brand speaker cables, thus sparing me the trouble of doing the same. He published the results in the July 1990 issue of *Hi-Fi News & Record Review,* and I trust his figures as completely as I am dumbfounded by his grading of the "pace," "ambience," etc., of each cable. (I have a fork that brings out the piquancy of sauerbraten like no other, Martin.) I can now plug the Colloms data into a circuit analysis program on my computer and obtain the response curve of any network formed by a known amplifier, one of the 44 cables, and a known loudspeaker system. Such a response curve will be accurate to the extent that the source and the load are modeled accurately.

The program I use is a relatively simple one: Micro-Cap II Macintosh Professional Circuit Analysis Program, Version 2.71, by Spectrum Software of Sunnyvale, California. The amplifier I used for modeling the interface in most of the analyses here was my trusty Boulder 500AE, which can be represented as a source impedance by an R of 0.01 ohm in series with an L of 2 μH—almost a perfect voltage source. I also did a few runs using the much more current-sourcey Carver Silver Seven tube amplifier instead, modeled by an R of 1.1 ohms. These values derive from actual measurements. The speaker system I chose to represent the load in my network model was the Carver "Amazing Loudspeaker" Platinum Mark IV, not so much because it's one of my favorites but because I was able to obtain a very accurate circuit diagram of it, showing every crossover and equalization component value plus the equivalent circuits of the transducers, including the motional impedance of the woofer system. I've decided not to reproduce the schematic here because I want to keep this discussion focused on speaker cables, not an interesting speaker design; just take my word for it that we have a nice, fairly complex, real-world load here, but not so difficult to drive that it could be objected to as untypical.

What the simulated response curves show.

Let's start with the aforesaid ideal situation, where the loudspeaker is being driven from an almost perfect voltage source (viz., the Boulder) without any cable—amplifier output terminals into speaker input terminals. Figure 2 shows the frequency response at that junction and proves that the fancy load represented by the Carver speaker looks barely different from a resistor to a voltage source. (Note that the upper limit of these simulations is 100 kHz—to forestall bandwidth arguments, as I've said—but it so happens that the Boulder does have a small-signal bandwidth of 200 kHz.)

Now let's insert 10-meter lengths of various speaker cables between the amplifier and the speaker to see how their different RLC values affect the response at the speaker input terminals. In a fair-sized room where the equipment, including the amplifier, is at one end and the speakers are at the other, 10 meters (32.8 feet) is a typical cable length, especially if the cable is routed along the baseboard or otherwise not dressed in a straight line.

Figure 3 shows the response with the least inductive and most capacitive cable modeled here, the AudioQuest Clear Hyperlitz ($50.00 per foot, plus $95/pair for prep). The low inductance limits the lowpass filter effect, but the 0.4 dB drop from 7 kHz to 12 kHz may conceivably be audible to the critical ear. I also want to mention that the MSSigma Series by Monster Cable (almost as costly) has highly similar RLC characteristics and will yield a virtually identical response.

Taking the cables in their order of increasing inductance and decreasing capacitance, we come to the Kimber 4AG braided silver cable, at $100 per foot (welcome to cuckoo country). Figure 4 shows the response. With about 50% higher inductance, 65% higher resistance, and totally

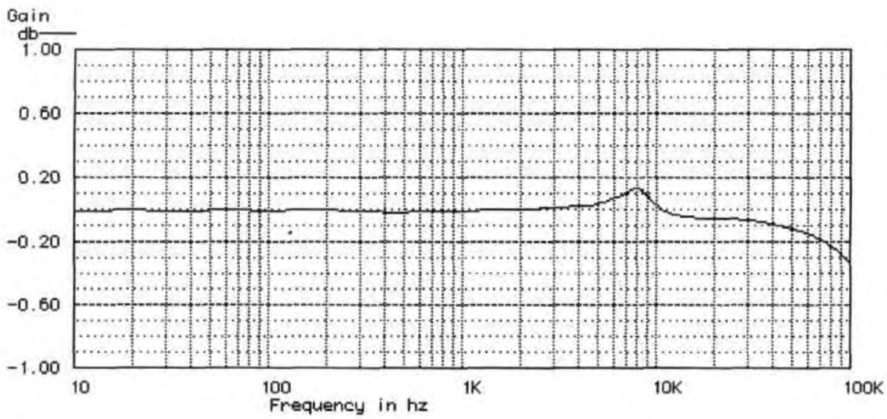

Figure 2: Response at the speaker input terminals with direct feed (no cable) from the Boulder amplifier. Note that the response stays flat within ±0.13 dB from 10 Hz to 50 kHz.

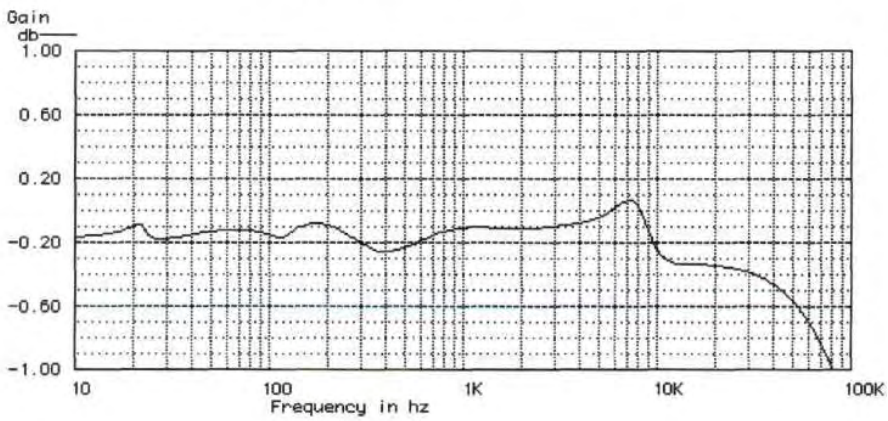

Figure 3: Response at the speaker input terminals with 10 meters of Audio-Quest Clear Hyperlitz cable driven from the Boulder amplifier. Note 0.4 dB drop from 7 kHz to 12 kHz.

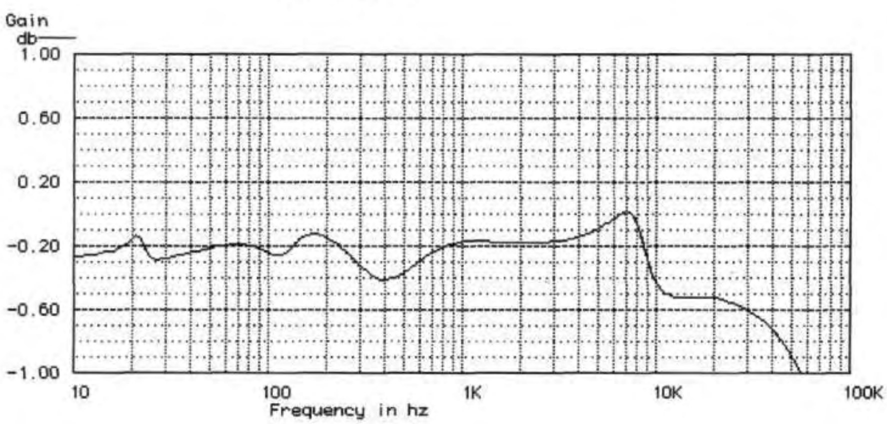

Figure 4: Response at the speaker input terminals with 10 meters of Kimber 4AG cable driven from the Boulder amplifier. Note 0.5 dB drop from 7 kHz to 11 kHz and 400 Hz notch.

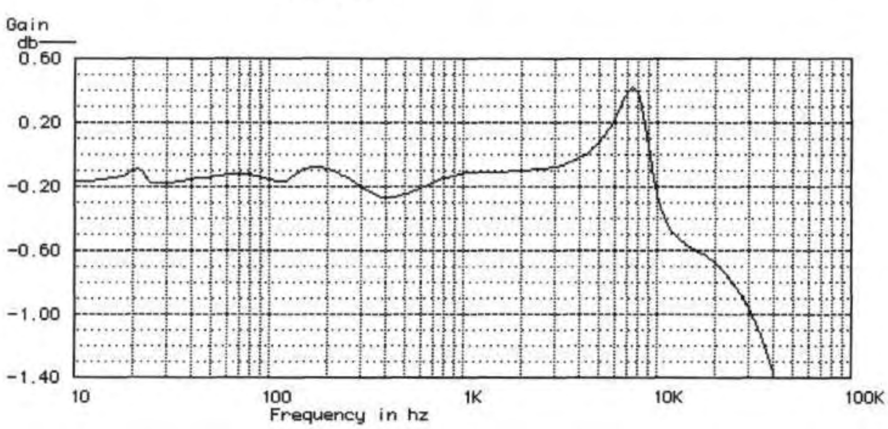

Figure 5: Response at the speaker input terminals with 10 meters of Monster Cable Standard driven from the Boulder amplifier. The drop from 7 kHz to 20 kHz is 1.1 dB.

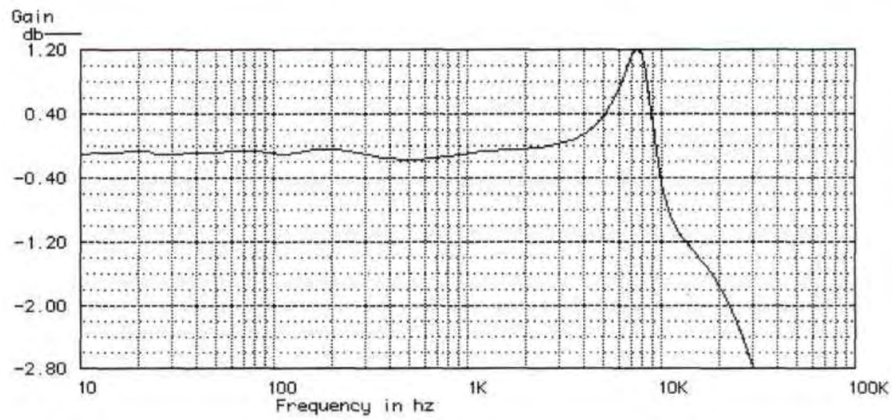

Figure 6: Response at the speaker input terminals with 10 meters of Siltech Ribbon cable driven from the Boulder amplifier. The drop from 7 kHz to 20 kHz is 3 dB. Note scale change.

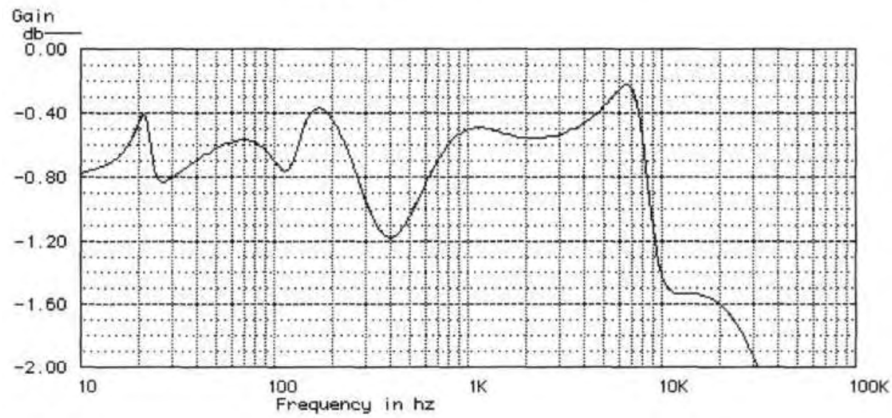

Figure 7: Response at the speaker input terminals with 10 meters of Vecteur 0.8mm solid copper cable driven from the Boulder amplifier. Note scale change back to original.

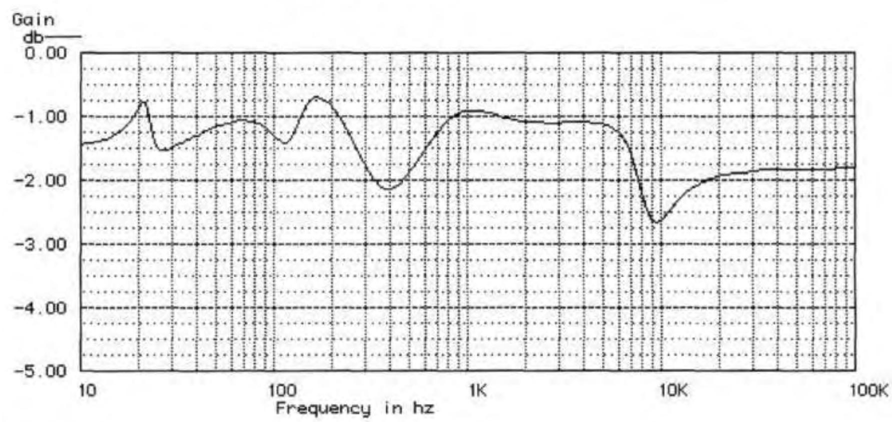

Figure 8: Response at the speaker input terminals with direct feed (no cable) from the Carver Silver Seven vacuum-tube amplifier. Note new scale change to coarser divisions.

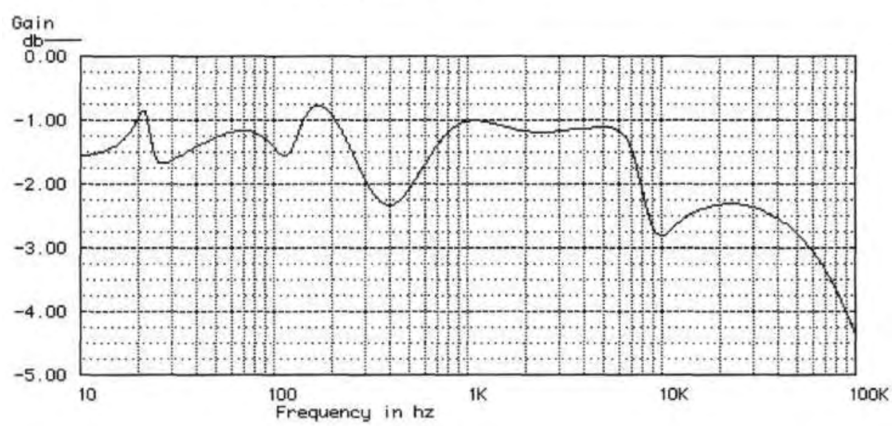

Figure 9: Response at the speaker input terminals with 10 meters of Monster Cable Standard driven from the Carver Silver Seven vacuum-tube amplifier. No change from direct feed!

different metallurgy/geometry, everything is worse by about 0.1 dB, without a change in overall profile. Big deal.

The relatively cheap Monster Cable Standard is next in line. It's almost four times as inductive as the AudioQuest and the response, as shown in Figure 5, is beginning to look like that of a mild lowpass filter. If a critical listener reported a slight softening of the top end with this cable, I wouldn't be the least bit surprised. Up to 3 kHz, however, the response is identical to that of the AudioQuest. Same bass, same midrange—not much possibility of an audible difference there.

Shall we go to extremes? Let's try a crazily inductive cable like the Siltech Ribbon from the Netherlands, by far the costliest of them all, made of extruded silver ribbon with perfect crystal structure, etc., etc. At approximately 2 μH per meter, it throws caution to the wind inductancewise, and a 10-meter length gives the response shown in Figure 6. Now that's a lowpass filter that even tin ears will easily hear in this particular system. (Martin Colloms heard it, too, and wrote, "Head and shoulders above the rest [the other 43 cables] was the Siltech Ribbon; yes—one hell of a price, but what accuracy!" Now, Martin used only a 5-meter length of cable, so he was putting 10 μH between his amplifier and his "predominantly...resistive 4-ohm" speaker, the KEF 105/3. A rough calculation translates that to a 2.4 dB droop at 20 kHz. That's accurate? Maybe to a golden ear...) This is clearly not the cable for long runs, unless the impedance of your speaker rises dramatically at the higher frequencies (and your banker calls you Mr. Getty).

Figure 7 illustrates a special case, that of the Vecteur 0.8mm solid copper cable, basically a tweako cult item but carrying a guarded endorsement by the illustrious Dr. Malcolm Hawksford *(Hi-Fi News & Record Review,* August 1985—and don't ask me to explain what he means). This is a much more resistive cable than the others; the 10-meter length modeled here represents a series R of 0.56 ohms, and its inductance is also quite high, between that of the standard Monster Cable and the Siltech Ribbon. The result is a weird roller-coaster-plus-lowpass-filter profile, not very promising sonically, unless you think an undulating ±0.7 dB response across the audio range is more acceptable in a speaker cable than in an amplifier.

But you ain't seen nothin' yet, folks. Take a look at Figure 8. That's a direct-feed, no-cable situation just as in Figure 2, except that the amplifier is the Carver Silver Seven, with its 1.1 ohm output impedance. It isn't only wire in the signal path that can alter the response! Here we have a ±1 dB characteristic, with most of the energy below 7 kHz on the plus side and everything above 7 kHz on the minus side. No wonder audiophiles talk about the "tube sound." A 2 dB range of fluctuation across the spectrum can be expected to be audible.

Here comes the mindblower. Figure 9 shows what happens when the Monster Cable of Figure 5 is used with the Carver Silver Seven instead of the Boulder. Nothing happens! The high-output-impedance signature of the tube amplifier is so dominant that up to 20 kHz the response is the same as it would be without the cable—and we're talking about a cable that has a distinct lowpass filter effect on this system when driven from a voltage source. Your typical high-end reviewer would probably report that the Carver amplifier isn't at all cable-sensitive—or maybe that Monster Cable Standard is somewhat amplifier-sensitive. "Where ignorance is bliss, 'tis folly to be wise," says the poet.

What does it all add up to?

The conclusions to be drawn from the above are fairly obvious, but let's spell them out.

No speaker cable of significant length is "accurate" in the sense that the signal is the same, or virtually the same, at the speaker end as at the amplifier end, but those with lower series inductance are more accurate than those with higher series inductance, as long as the series resistance is reasonably low. Metallurgy is irrelevant to accuracy, and construction is relevant only to the extent that it controls the series inductance per unit length (and, possibly, the cable's susceptibility to RFI, a subject I have yet to address). Price is also irrelevant, except that very low-inductance speaker cable is never dirt-cheap. Shunt capacitance is of little or no consequence as long as the amplifier is perfectly stable, an assumption made in all of these simulations but not always the case in the real world. Finally, if the amplifier isn't a voltage source—i.e., if it has a high output impedance—all cable characteristics will be swamped, except in the most extreme cases.

What about the sound? Obviously, two speaker cables as similar in response as, for example, the AudioQuest Clear Hyperlitz and the Kimber 4AG can be expected to be indistinguishable in a double-blind listening test. As I have always insisted, A and B will inevitably sound the same unless there exists some kind of mechanism whereby they can sound different. (Weird reasoning, isn't it?) In this case, a difference of 0.1 dB is an insufficient mechanism. On the other hand, a cable like the Siltech Ribbon is so different in response from the others that I'd be astonished if an experienced audiophile couldn't distinguish it by its sound. The point is that speaker cables will sound the same or different according to their RLC characteristics, not according to the voodoo criteria of the cable cultists. Thus, if you inserted a small circuit board with the proper RLC values—costing maybe $2.00 or thereabouts—between the amplifier and the speaker in the direct-feed signal path of Figure 2, you could obtain the Kimber 4AG silver cable's exact response as shown in Figure 4, at a saving of thousands and thousands of dollars. (That's Larry Archibald's and Dick Olsher's cable, if you'll forgive me some name-dropping.)

So what's the best thing to do?

The best advice must be practically staring you in the face at this point. Simply avoid long runs of speaker cable—any speaker cable, no matter how good you think it is. In most installations, that's eminently doable. With a pair of mono amplifiers, you place each amp directly behind each speaker and make the connection with a minimum amount of wire—any kind of wire. When you're talking inches or a foot, the RLC values simply don't matter. Or, if you have a stereo amplifier, place it right between the two speakers and use four of five feet of wire to connect each speaker. Make it 16-gauge or thicker—ordinary lamp cord is fine—and forget about the L and C values because they'll be quite negligible at that length. The whole thing becomes a nonissue.

Where do you put your preamplifier? With balanced lines, you can put it at any distance from the power amplifiers). With unbalanced lines, you can usually put it just as far away, but make sure that you have no hum and no RFI. In the worst case, if you have serious problems with long unbalanced lines, put all your stereo components between the speakers, especially if you play mostly CDs. (Only turntables tend to be affected by the sound field in the proximity of the speakers.) In the age of the remote control, such a deployment—with short wiring everywhere—has become quite convenient. Use long speaker cables only as a last resort. What kind, if you must? Chris Russell, mastermind of the Bryston amplifier company, recommends RG-8 coaxial cable, which is lower in inductance than spaced 2-conductor types and only slightly higher in capacitance (meaning that the 10-meter profile would fall somewhere between Figures 4 and 5), has a 13-gauge center conductor, and costs 42 cents per foot at Radio Shack. Now *that* sounds good to me.

One more thing.

Before I sign off—until Part III, that is—I'd like to return very briefly to the bandwidth issue and register a word of protest against what I consider to be the most misleading speaker cable advertising of all—because it looks so scientific on the surface. I'm talking about those highly technical MIT (Music Interface Technologies—definitely not Massachusetts Institute of Technology) ads and brochures showing all kinds of oscilloscope pictures of impulse response, "phase noise" (their term, not mine), and other time-domain performance characteristics of MIT cables, in documentation of their alleged technical superiority. The trouble is that the time axis in the scope pictures either isn't labeled at all, or else the time-per-division information is buried somewhere in the small print. The technically unsophisticated audiophile looking at the ads and brochures is under the impression that he is being shown superior performance in the audio range, whereas in reality all of that time-domain action is happening in nanoseconds, totally unrelated to the audio range (which extends, even with our agreed-on stretching, only from 67 milliseconds to 20 microseconds). MIT is selling *megahertz* performance to the *audio* market for big bucks. Not that they're the only snake-oil artists among the cable vendors, but I happen to be particularly irritated by their kind of scientific non sequitur. The only thing that irritates me even more is that a few years ago I allowed one of those ads to slip through into the pages of this publication. I don't think, however, that cable advertisers will be breaking down my door from now on. ¥