A Tiny History of High Fidelity, Part 1

A Rainy Night in Portland, 1936.
Thanks to the restoration movement, much of downtown Portland still looks like this.

Where do I come from?
Where am I going?
Who am I?
These ancient questions are with us still. With only the slightest of changes, they can be recast into a form that provides a guidepost to the music lover, the audiophile, the hobbyist, and the artisan-engineer.

Where does the art of sound reproduction come from?
Where is it going?
What do I seek from this art?

Radio!
1900-1930

In the first years of Electrical Amplification, engineers had their hands full just trying to master the complex and non-intuitive mathematics of vacuum tube amplifiers and oscillators. It is worth keeping in mind that vacuum tubes **were** electronics in the first half of the Twentieth Century; before Lee DeForest modified Edison's light-bulb, the only form of "amplification" were relays that could repeat and rebuild telegraph signals. Radio relied on tuned circuits, massive brute-force spark-gap transmitters, large long-wave antennas, and crystal-diode rectification that directly powered the headphones. The faint signal that wiggled the headset

diaphragm was a infinitesimal fraction of the megawatts that poured in all directions from the transmitter. Records, of course, were purely mechanical and acoustic, and wouldn't work at all if it weren't for horn-gain in recording and playback. What we now think of as electronic engineering back then was **electrical** engineering, focussed on keeping AC power transmission systems in phase and specialized techniques for pushing a telephone-audio signal down hundreds of miles of wire without benefit of amplification.

In the 1910's, the engineers of the Bell Telephone System improved the unreliable and short-lived DeForest Audion by increasing the vacuum, removing manufacturing impurities, establishing the requirement for negative bias, and creating the first mathematical models of diode rectification and triode amplification. The Bell System desperately needed to improve the quality and reliability of long-distance service, and the amplification provided by the first triodes answered the need. Radio Corporation of America was created as a US government monopoly during the first World War to employ the vacuum tube for improved radio reception, and as a direct result, ended up controlling most of the patents for vacuum-tube technology for the next two decades.

In the early 1920's, Major Armstrong (who went on to invent and patent superregeneration, the superheterodyne, and FM radio) built on the work of Bell Labs and RCA by accurately characterizing the electrical behavior of the simple triode and establishing the requirements for correct biasing and plate loading. All of these developments opened the door for rational and predictable design of audio and radio-frequency (RF) amplifiers, which led to a very rapid expansion of the radio industry, public address systems, movie sound, and the introduction of electrical phonograph recording and playback. It is worth contemplating when we pat ourselves on the back for the rapid progress of the Internet that the entire field of electronics went from a strange laboratory curiosity (before World War I), to the first AM radio broadcasts by KDKA in 1920, to a mature and very fast-growing field (dominated by enormously profitable monopolies) at the beginning of the Thirties.

One aspect of the new maturity of electronics was the idea that music could actually sound something like the concert-hall experience. You no longer had to shout into the telephone if you made a city-to-city call; sensitive radios could tune in broadcasts across continents; it was now possible for police in radio cars and pilots in aircraft to talk to central stations and get directions. Electronics had arrived, but considering what was possible, much more could be done.

In the days of noisy, fast-wearing 78rpm records and narrow bandwidth AM broadcasting (the highest-quality long-distance lines of the Bell System limited the signal to 50Hz - 8kHz), the best that could be hoped for was "Good Tone." Although hundreds of manufacturers of radios and phonographs were continually striving to improve quality, the built-in limitations of shellac records and the AM broadcasting networks made it difficult to go very far in improving loudspeakers and amplifiers without further exposing the problems of the source. This is why the early subjective studies by Bell Labs about the prospects for high-fidelity were rather unpromising; prototype microphone and speaker drivers did actually go from 40 Hz to 15 kHz (or rather, kilocycles), but after shellac records and AT&T long lines got through with the signal, the extra bandwidth added aggravation and fatigue, not listening pleasure. It's always worth keeping in mind when looking at old schematics that low-noise, wideband signal sources simply didn't exist back when the designs were new, and that modern triode fans are having a completely new experience when playing them with modern signal sources and loudspeakers.

Going to the Movies
1930-1940

The major advancements of the Thirties came from the movie industry, which was free to build complete sound systems from the ground up. The Hollywood studios were vertically integrated businesses, with each studio owning their own chain of theaters. This meant the studio controlled everything from the performer, to the microphone, to the auditorium, and everything in between. There was no need to fit anything into the restrictions of commercial radio, records, or consumer-grade electronics. Each studio was in direct control of the entire artistic, technological, and commercial experience of "going to the movies."

Movie producers and directors quickly discovered that sound was the heart and soul of the movie, conveying emotions powerfully through music, underpinning the dialog and the images, giving the "talkie" a profound emotional impact denied the silents. The "talkie" aspect removed the tedious need for title cards, but the impact of music and sound-effects made it possible to make new kinds of movies that affected the audience in a deeper way than before.

The standard art criticism of early sound-film rightly focusses on the loss of camera-movement freedom that happened in the early Thirties (the first "blimped" cameras were extremely large and heavy). What has been forgotten is that producers and directors entered a new artistic realm with live dialog and music, a change that ushered in a more subtle and intimate form of acting, and musical moods that mirrored the inner feelings of the characters. After sixty years, we take this for granted, but the combination of sound and film created a medium that was unexpectedly different from its component elements of music on records and silent film.

The movie industry quickly discovered that improved fidelity (from optical sound, better amplifiers, and better speakers) deepened the emotional effect of the sound-track. For the first time in the history of the movie industry, sound quality, even if it wasn't consciously noticed by the audience or the critics, became a powerful and profitable box-office draw.

Both Western Electric (the manufacturing and R&D arm of the Bell Telephone System) and the RCA/NBC system competed to design the highest-quality sound possible. In the 1930's, movie sound was the leading edge of the entire electronics industry. Unlike the pervasive Microsoft monopoly of today, which has essentially no competition in key sectors of the computer industry, RCA and Bell Telephone were in direct competition in the movie industry, and engineering teams from each side continually vied to one-up the competition. (Where would Windows, Office, and Internet Explorer be if an equally powerful and well-financed competitor matched Microsoft with every new release?)

In the brief span of a decade, the entire foundation of the modern high-fidelity industry was created. Between 1929 and 1939, the world saw:

- In 1936, the first demonstration of long-distance high-fidelity using all-FM transmitters, repeaters, and receivers by Major Armstrong and his affiliated FM Network. This could well have been the first public demonstration and commercial sale of full-frequency-range, low-distortion, high-fidelity sound for a mass audience.

  The Yankee FM Network and its national affiliates was almost certainly the first opportunity the public had to experience full-frequency-range, wide-dynamics, and low distortion on a day-to-day basis. The only alternatives were noisy shellac 78rpm records, low-fi network AM with limited-bandwidth intercity relays, and optical soundtracks with modest performance at best. Armstrong's network was the first complete high-fidelity system to make it out of the lab into the hands of the public - and the original high-power, low-band Armstrong FM system continued broadcasting until 1945, when the FCC moved the FM spectrum to its

current location of 88 to 108 MHz.

- Two and three-channel stereo sound demonstrations by RCA, Western Electric, and Alan Blumlein, and the first full-length movie to use a multichannel soundtrack, Walt Disney's *Fantasia*, released in 1940.

- Alan Blumlein went on to invent, patent, and prototype an *entire stereo signal chain*, with crossed-pair figure-8 microphones, matched low-distortion electronics, 45-45 moving-coil cutterheads with motional feedback, moving-coil 45-45 phono cartridges, stereo-optical soundtracks, and matched stereo speakers. (Blumlein also analyzed and found means to circumvent what is now called Miller capacitance, and invented the long-tail pair differential circuit.)

- Low-distortion, full frequency range microphones, phono pickups, amplifiers, and speaker systems from Western Electric, RCA, Decca, EMI, and others. The most advanced equipment was used for transcriptions of radio shows (via 16 and 33rpm acetate masters) and in high-end radio sets.

- Electroacoustic analysis and modelling of microphones, moving-coil cutterheads, optical modulators for movie soundtracks, phono pickups, direct-radiator loudspeakers, and theatre horns.

- The first widely used vacuum tube was the direct-heated (usually battery powered) was the RCA '01A direct-heated triode in 1922. This became the general-purpose tube of the 1920's - in the late Twenties, specialized tubes appeared, starting with the indirect-heated RCA '27, followed by the closely related 37, 56, and 76. These low-level tubes made AC-powered radios possible, since they didn't require battery power for hum-free operation.

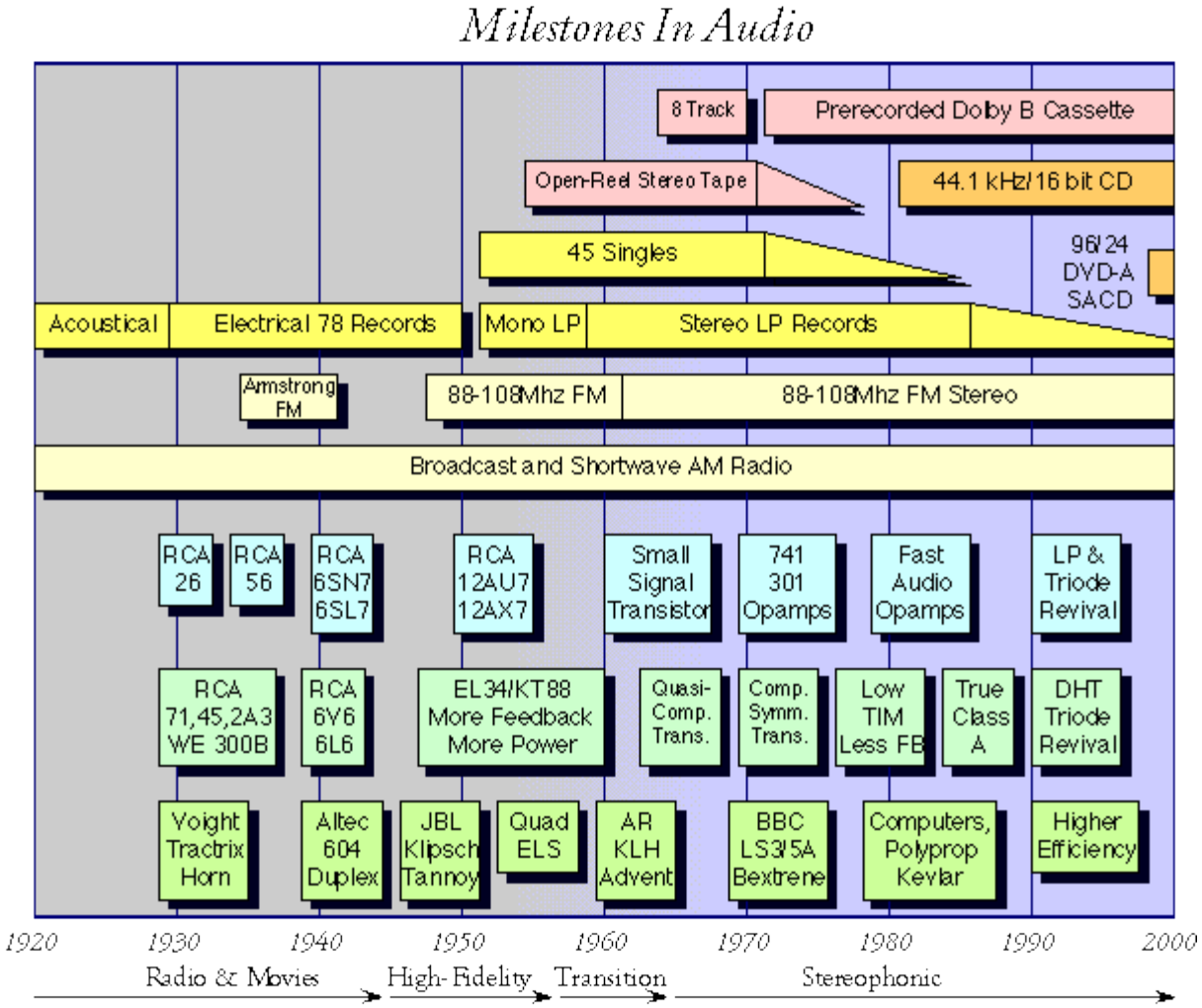
  In 1926, '71A direct-heated power triode was introduced, followed by the '50 in 1928, the '45 and PX4 in 1929, the PX25 in 1930, the 2A3 in 1932, the 300A in 1936, and the 300B in 1938. The power race started in earnest with the 6L6 and KT66 pentode in 1936, followed by the ubiquitous EL34 in 1951, the EL84 in 1953, the 6550 and KT88 in 1954, and last in the series, the 7591 in 1959 and the 8417 in 1963. (The 6L6 has been in continuous production since 1936, a record unmatched by any other electronic device - we all owe the electric-guitar players a big *thank you* for keeping the tube factories open.)

  Seventy years later, vacuum tubes, and especially triodes, continue to be the lowest distortion amplifying elements ever made. No germanium or silicon transistor, JFET, or MOSFET has ever approached the distortion performance of the direct-heated triodes, with indirect-heated triodes following closely behind. In addition to low distortion in the absolute sense, the distortion spectra of triodes is favorable, with a rapid fall-off of the upper harmonics. (This is less true for beam tetrodes, pentodes, or solid-state devices, which are intrinsically less linear and have higher-order distortion curves.)

  If you ever want to put a solid-state designer on the spot, ask them which transistors were designed for high-fidelity audio applications ... and **are they still on the market**, ten or twenty years after they introduced? You can expect a long silence after this question - when a transistor model goes out of production, that's it. Don't expect to find stocks of obsolete transistors, and you can be very sure that nobody wants to collect them or use them in a vintage-sound product.

The sad fact is that solid-state devices have linearity well down on the list of design priorities, with feedback needed to clean up devices that were never primarily intended for audio. The automotive equivalent would be cars modified to use truck diesels ... OK for Soviet Russia maybe, but do you think *you'd* want to buy something like that if you had a choice? Yet this is the state of affairs in solid-state audio, with the electronic equivalent of an industrial diesel pressed into service in so-called "high-end" electronics.

- Returning to the Thirties, the first commercial application of loudspeaker time-alignment. (Designed at the request of a movie director who was not satisfied with the realism of tap-dancing on the soundtrack!)
- Bi-amplification for lower speaker & amplifier distortion and wider dynamic range. This was used in theatre systems, sound reinforcement, and top-of-the-line radio sets.
- And many *other* innovations still in use today.



The "Golden Age" of High-Fidelity in the Fifties and the "Ultra-Fi" direct-heated triode movement in the Nineties onward have drawn deeply from the wellspring of knowledge created in this decade. The papers of Major Armstrong, Alan Blumlein, and the RCA and Western Electric research labs make fascinating and instructive reading today. In audio, we truly stand on the shoulders of giants. No succeeding era was even remotely comparable to the accomplishments of the Thirties - what followed was more of a process of consolidation

and a gradual diffusion of technology out of the laboratories to more and more listeners at lower and lower prices.

Anytime you read a glossy ad in a magazine, or see an animated corporate logo in the movie theater, think back on what the pioneers created with little more than knowledge of fundamentals, adding-machine calculators, and slide rules. It is a little sobering to realize the time we've wasted making digital recording approach the quality of the analog tape and LP's they needlessly replaced ... *20 years* ... is the same time span from primitive Edison cylinders and crystal radio to all-FM broadcast networks and 3-channel Stereophonic Sound (called Auditory Perspective back then).

We have more audio engineers than ever, and far superior analytical tools, but what does mainstream audio engineering have to show for the last two decades? Seriously?

Crap like AC-3, MP3, and AAC digital compression techniques? Watermarking techniques that are inaudible to teenagers listening on Internet-downloaded MP3s? With the industry's Best and Brightest working on projects like these, is it any wonder that progress is coming from industry outsiders?

The Baton is Passed
1940-1950

The War Years of the Forties represent a fallow period for audio, as the best minds of the electronics industry turned away from audio to devote their energies to building high-frequency radar systems, and after the war, the fast-growing television industry. This period also represents a turning of the generations, as the first wave of audio pioneers passed the baton to the engineers who would later build the Golden Age of High-Fidelity in the 1950's.

One of the most important developments of the late 1940's was the introduction of the Williamson amplifier, which finished off the use of power triodes in high-fidelity (except for a very small group of French, Italian, and Japanese hobbyists). With the introduction of the high-feedback, high-power, and high-efficiency KT66 Williamson, the great power and distortion-lowering race began in earnest, and would continue relentlessly for the next 40 years.

Although it may seem easy in retrospect to criticize the high-feedback Williamson now, we should remember what the speakers of the late Forties were like: there was no real understanding of the properties of closed-box or vented-box systems, and most speakers were boomy or thin-sounding (mistuned) by modern standards.

With a closed box (known then as infinite-baffle or acoustic-suspension), the tuning problem is straightforward ... just adjust the box volume for flattest response and best sound. Build two or three boxes, and one is bound to be right. However, a vented box is a *fourth-order* system, and system tuning becomes horrendously difficult by the cut-and-try methods then available. Even something as basic as *measuring* a closed or vented box is quite a difficult trick. Modern analytic and near-field measuring techniques were still 20 years in the future, awaiting the Audio Engineering Society (AES) publication of the Neville Theile and Richard Small papers in 1971.

The high damping (due to high feedback) of the Williamson was just what the boomy speakers of the day needed, offering a genuine improvement in bass quality. The increased power was also appreciated, since the 2A3 was the only power triode then available to the public ... the much larger 300B was not available to the public, and the 211 and 845 transmitting triodes

require large and dangerous high-voltage supplies. The combination of high power, high damping, and easily available power tubes in the 6L6, 807, KT66, and 5881 family met the needs of a new generation of postwar audiophiles. The Williamson was so successful that it swept nearly all other circuits aside; a review of American hi-fi magazines from the late Forties to the mid-Fifties shows one Williamson article after another, with rare exceptions for McIntosh, Quad, or the oddball novelty circuit. The spell of the Williamson was finally broken in 1957-59, with a flurry of new Ultralinear EL34 and KT88 products from Dynaco, Acrosound, Marantz, and Citation.

A more significant event of the late Forties was the introduction of the Ampex magnetic tape recorder, based in turn on captured German Magnetophon AC-bias machines. What was a little odd was that the German AC-bias technology was known in America and the UK before the war, but ignored by the English-speaking audio industry in favor of lo-fi wire recorders using DC bias (dictation machines). In the immediate postwar period, the problems with manufacturing iron-oxide coated magnetic tape were mastered by 3M, and the new Ampex tape recorders quickly surpassed the German originals. The introduction and rapid improvement of magnetic tape recording was *the* prerequisite for the broad advances of the 1950s.

The advent of high-quality 30 and 15 IPS master-tape recording (which still sound astonishingly good 50 years later ... check out the RCA Living Stereo and Mercury Living Presence reissues) meant that the recording, movie, and broadcasting industries finally had the means of making superior-quality original productions ... but no way of distributing them to the public! The fruits of this research ignited the second wave of audio, the Golden Age of the 1950's.

The Golden Age
1950-1964

In the early Fifties, Columbia Records introduced a Long-Playing 12" 33 1/3 rpm record, and RCA introduced a competing 7" 45 rpm record (later known as the "single"). Both formats combined a standard-width microgroove, low-noise vinyl, sapphire or diamond styli, and much lower playing weights. This resulted in a phonograph record with far better durability, dynamic range, and playing time. What was known as the "battle of the speeds" ended with 3-4 minute popular songs being released on 45 rpm, and longer "serious" jazz and classical music coming out on 33 rpm. (The stereo-LP "rock album" didn't appear until the mid-Sixties. Before that, rock-n-roll was a niche market for teen-agers, almost entirely restricted to disposable lo-fi mono 45's pressed on recycled vinyl.)

At the same time in the early Fifties, the broadcast industry opened hundreds of new high-quality FM "Good Music" stations carrying classical, jazz, and light popular music. The new FM stations were subsidized by the established mass-market AM stations, allowing FM stations to carry more specialized programming. In the United States, the era from the early Fifties to the mid-Sixties represents a high-water mark for musical and technical broadcast quality, which has never been equalled before or since. The quality that is taken for granted in Europe or Japan was gradually driven out of the US market by commercial market-share considerations that eventually resulted in FM mimicking the technical and programming practices of the AM market. It's no accident the era of the best FM tuners mirrors the best broadcasting. The history of audio shows that program and technical quality go hand in hand; when one go up, the other follows, and when one goes gown, the other follows.

Hollywood met the challenge of early black-and-white television with 6 discrete channels of

magnetic sound on the 70mm wide-screen Technicolor, a tremendous advance on the traditional single optical channel on 35mm film. Cinerama, CinemaScope, VistaVision, and Todd-AO 70mm gave the movie-goers a dramatic and unforgettable new experience. (Modern 35mm films exhibited in small theatres are much *lower* quality than the 70mm mag-track films of the 1950's, with exhibition quality little better than home theater. The IMAX and OmniMAX films shown in specialty theatres is the only modern format that exceeds the performance of 70mm and 3-screen Cinerama, but IMAX sound quality is still well below the sonics of mid-Fifties all-analog all-vacuum-tube first-run movie theaters.)

All of these parallel advances (which happened in *less than a decade!*) led to the birth of a new industry, quite separate from the mass-market radio-phonograph consoles ... the "High Fidelity" industry. The industry grew in direct response to the explosion of high-quality music from many different sources; without all of these new sources of high-quality, high-fidelity music, there couldn't have been a Golden Age of audio.

Many treasures from this era still delight us today ... truly wonderful recordings that are clearer, more natural, and more lifelike than contemporary digital recordings made 40 years later. We also have legacy of superb products made by Acrosound, Altec, Ampex, Brook, H.H. Scott, Fisher, JanZen, Leak, Marantz, McIntosh, Ortofon, Quad, REL Precedent, Tannoy, and Thorens, to name just a few. Even the budget-priced Dynaco Stereo 70, made in the hundreds of thousands, still gives great musical pleasure with the very latest speakers and SACD players of the new Millenium! This was a period when the pioneering advances of the Thirties spread out across the world, with many millions now enjoying high-fidelity for the first time.

The decade saw a major transition from a hobbyist-driven pastime to a widespread domestic industry, with products growing more elegant, easier to use, and domestically acceptable. Amplifiers became more powerful, receivers were introduced, and speakers followed the lead of AR and KLH in getting smaller. Relative to the precipitous decline of the early transistor era, though, the sonic compromises of the 1950's were moderate, and more than offset by a great abundance of new music from stereo reel-to-reel tape, superb LP recordings, and live FM radio transmissions (with none of the compression and dynamic EQ that is standard commercial FM practice today).

One of the things **not** mentioned in the current nostalgia boom for the 1950's is that the pace of technological and social change in the late Fifties and Sixties was stunningly fast ... much faster than the last twenty years, which has a great deal of excitement in the computer field, but precious little elsewhere, and is actually a period of social and political reaction. For us, the future is a subject of grim fantasy in movies and fiction, but back then, it was very real and something to get excited about.

In the time-span of 1954 to 1964, TV changed from black-and-white to color, audio changed from table radios and massive "French Provincial" consoles to elegant stereo components, very high-quality FM radio became widespread, aircraft changed from slow and noisy Super Constellations and DC-7's to fast and quiet Boeing 707's, interstate travel changed from congested 2-lane roads with many traffic lights to freeways, and space exploration changed from an impossible science-fiction dream to everyday reality. The social changes were equally profound ... rock-n-roll emerged from the unsavory ghetto of "race music", the civil rights movement began to reverse centuries of racial brutality, and the stodginess, conformity, and social repression of the 1950's relaxed into the Utopian freedom and experimentation of the 1960's.

Returning to our little pond of hi-fi, this dramatic era of technical and social advancement was a perfect time to change a fast-growing industry from monophonic to stereophonic sound. The

decision-makers in the record industry sat down at a table in Los Angeles in 1958 to decide which of the 3 competing systems was going to be the world standard ... and even more remarkably, **they made the right choice!** (Compare that to the corporate infighting and complete lack of compromise just 14 years later when quad sound was developed, or the current wrangle between SACD and DVD-A.) The Westrex 45-45 stereo system became the world standard for 33 and 45 rpm records, and in less than 2 years time, nearly all titles were being simultaneously released in both stereo and mono. (The $1 dollar difference in price is the real reason that flea markets are glutted with unwanted mono LP's today.)

As stereo sound gradually replaced mono, the large horn and infinite-baffle speakers of the early 1950's fell out of favor. It's one thing to have a handsome big speaker in the corner of the room ... after all, it's kind of a conversation piece, like a grand piano ... but **two** behemoths (with additional demands for stereo symmetry in room placement) are quite another story!

The advent of stereo moved the "bookshelf" speakers (so-named because they were always shown in the advertisements of the day as fitting in a bookshelf of a built-in library) from a New York studio-apartment curiosity to the hi-fi mainstream. Acoustic Research was the pioneer with the "acoustic-suspension" principle used in the AR-1 in 1954, and as the decade moved on, the AR-3, AR-2, and AR-4. Kloss, one of the co-founders of AR, went on to form KLH, which made speakers very much in the pattern of the original AR family.

It wasn't just small size that made the bookshelf speaker a success. The AR and KLH speakers had much flatter frequency response than the big competitors, and the smaller cabinets were far more rigid than the large and thin plywood cabinets of the old-timers. Although the big speakers had lots of dynamics and impact, the AR's and KLH's had much less coloration, and introduced the concept of accuracy to the public at large. In North America and Britain, the low-efficiency compact speakers became the dominant metaphor for true high-fidelity, and the big horns were seen as archaic and regressive. In other parts of Europe and Japan, though, the big horn speakers never lost their following, since audiophiles in those markets put more value on dynamic range and low distortion than flat response and "accuracy" in the Anglo-American sense.

At the same time as AR and KLH were making a big splash in North America, D.E.L. Shorter of the BBC was laying the foundation of modern speaker design by uncovering and measuring the elusive "delayed resonance" that didn't show on up on conventional swept frequency measurements ... eventually leading to the FFT and MLS techniques used today. Although it took many decades, the delayed resonance measurement technique finally made it possible to build conventional dynamic speakers that rival the single most advanced speaker of the 1950's ... the Quad electrostat.

The first Quad electrostat (abbreviated either as ESL57 or ELS57) occupies a very select circle of classic speakers that still sound "modern", even advanced, today. Even in strictly objective terms, the Quad has superb transient response, with nearly perfect square waves, as well as vanishingly low IM distortion. Very few modern speakers combine excellent transient response with low distortion; most speakers, then as now, force the buyer to choose between very low IM distortion (horns and studio monitors) and excellent impulse response (linear-phase audiophile speakers).

As efficiencies of the "bookshelf" speakers gradually dropped, amplifier power increased to compensate, with the 15 watts of the KT66/6L6 Williamson growing to the 35 watts of EL34 family of amplifiers and the 60 watts of the KT88/6550 family. The enduring classic of this era is the well-loved Dynaco Stereo 70, with over 500,000 in production over 30 years. Although

the circuit of this amplifier is hardly sophisticated or even particularly linear, a carefully-restored Stereo 70 still sounds better than many high-end amplifiers made today!

In 1963, the FCC selected the Zenith subcarrier system for stereo FM (which was probably not as good as the Crosby FM-FM system, but still a reasonably good choice), and now FM radio became stereophonic as well. The only offshore competitor was the inferior Halstead system, which was actually a mono signal steered left and right by a low-frequency control signal. Fortunately, when the BBC was deciding on a stereo FM system, they were wise enough to discard the home-grown system, and adopt the foreign Zenith system. In time, the Zenith system became a world standard, a rare example of international harmony in broadcasting standards. Anyone who has followed the endless wrangling regarding color and high-definition television knows how rare it is for US and European technical committees to agree on *anything!*

Stereo sound for television was set aside in 1964 by the FCC at the request of the three major TV networks (so they could avoid additional costs at the time they were converting to NTSC color). Stereo television sound would have to wait 20 years for the eventual adoption of a system that was remarkably similar to the original Zenith proposal (with the addition of DBX compression for the L-R difference signal).

Any discussion of golden-age hi-fi always gets around to speakers. Thoughtfully restored electronics from the period give impressively good ... and very modern ... sound when put in a contemporary system with reasonably efficient speakers. What about restored Golden Age speakers? It's not so simple with speakers. Yes, there are a few classics, starting with the legendary Quad ESL. Bear in mind that the Quad has very serious problems with dynamic range compared to modern speakers, and the "sweet spot" for stereo is little more than 2 feet (or less). The dynamic drivers are a tough choice: the sonics of the West Coast high-efficiency classics like JBL's and Altecs are not to everyone's taste (especially classical-music fans), and the East Coast favorites like the AR and KLH are inefficient and low in resolution (high IM distortion, crude crossovers). The tweeters are typically very poor, with high distortion, lots of stored energy, rough response, and ragged polar patterns. Tweeters and phono cartridges are intimately dependent on materials technology, and in all honesty, the materials we take for granted today weren't available to NASA or the SR-71 Blackbird Skunkworks team back then.

But again, even here there are exceptions. Cone tweeters are unjustly forgotten, especially the Bozak and Peerless 2" paper cones with a 3/4" aluminum dustcap. These are really quite good, and far better than the wretched dome tweeters of the era. It wasn't until the Nineties that 1" dome tweeters began to catch up with the cone tweeters of the Fifties and Sixties. Vintage horn tweeters are anywhere from really terrible to pretty good; just don't expect anything beyond 15 kHz or broad dispersion. I still prefer the sound of phenolic diaphragms to aluminum - one of the reasons I've never warmed up to the Altec/JBL sound, which has always sounded metallic to my ears.

Dome midranges, then as now, are pretty dreadful, with very high IM distortion thanks to side-to-side rocking (no spider, after all). The old-school East Coast speakers are essentially impossible to modify, because after you replace the drivers, the enclosure, the crossover components, the box filling, the grill cloth, and the speaker wire, all that's left of the original is the logo on the front.

What's desirable are paper-cone drivers with Alnico magnets ... although the Qt may be impossible to use in a flat-response closed or vented box. (Look for Qt between 0.2 and 0.38; any lower, and there will be a very high F3 frequency, any higher, and the alignments start to get unreasonable in terms of box size and response shape.) Be aware that drivers intended to

be used in horns have very limited excursion, and may even be destroyed if used in a closed or vented box.

The reputation of Alnico magnets is not just hype and hokum; the difference is real, and the reason is simple. All dynamic drivers are inductive at some frequency; for a bass or midbass driver, the inductance becomes significant from 300 to 500 Hz on up (even if the measured frequency response is flat to 3 kHz). The electrical rolloff due to voice-coil inductance is counteracted by a rising mechanical response (just like a moving-magnet cartridge).

The voice-coil inductance is always there, and always in series with the audio signal path; what goes unnoticed is exactly what kind of inductor it really is. Well, of course, it's an iron-core inductor, so there are linearity issues to contend with. Not surprisingly, ferrite-core inductors are very different animals than Alnico-core inductors. The best of all would be soft iron, as used in antique electromagnet speakers, but you have to go back to the Thirties for that technology (or have them built in Japan).

The copper-clad pole-piece of modern Scan-Speak, Skaaning, and Vifa drivers is a good start, getting rid of 60-90% of the VC inductance, but's what left is still that ferrite core. One day, just maybe, we'll see a modern speaker with a copper pole piece and an Alnico or electro-magnet. This would be very interesting and would combine the virtues of the Thirties, Fifties, and Nineties all in one driver. Until then, you can choose between vintage sound (with the charms of high efficiency and Alnico magnets) and modern drivers with their very low coloration and high-tech cones.

The advancements in audio electronics since the Golden Age have been in cost and size reduction, not audio quality. In real dollars, electronics are far. far cheaper now than they were 40 years ago. A Sears Silvertone table radio, for example, cost $39 in **1956** dollars, back when gold was $35 an ounce, a Chevrolet Bel Aire $1295, or a nice house $10,000. That effectively makes a basic Silvertone AM radio $400 to $1000 in modern terms. Would anyone pay $1000 for a table radio now? Of course not (unless it was Bang & Olufson maybe). But despite the truly impressive cost reduction, it's difficult to claim that modern electronics are actually better in musical terms. They measure better, but the actual physical devices that do the work are industrial castoffs with very complex nonlinearities.

By contrast, speaker technology **has** advanced since the Golden Age, mostly thanks to materials technology and greatly improved modelling. But the advances have been uneven, with setbacks in efficiency, IM distortion, aggressive cost-cutting, and unsatisfactory musical balances. This makes choosing a vintage speaker a more challenging decision. As mentioned above, my personal preferences would be drivers that would combine the best of each era ... efficiency, low IM distortion, modern cone materials and suspensions, and voice-coil-friendly magnets.

Part 2

First published as "The Soul of Sound" by Lynn Olson, revised and updated in 2005.

A Tiny History of High Fidelity, Part 2

A Near-Death Experience for High Fidelity
1964-1970

In the latter part of the Sixties, the High Fidelity industry continued to grow, but the pace of innovation slowed down after the conversion to stereo sound. More ominously, the transistor revolution proved the undoing of the domestic Hi-Fi industry. (This is why the Hi-Fi line in the Markets chart breaks off around 1968 ... sadly, the dreams of many Americans came unraveled in those bitter years, with the triple assassination of both Kennedys and Martin Luther King.)

To return to the story of audio, the early transistor amplifiers used the notorious quasi-complementary output scheme, since matched complementary output transistors were not then available. In addition, the dangers of exceeding the Safe Operating Area were very poorly understood, so the first generation of transistor amps weren't even remotely "solid-state reliable." Instead, they failed at the drop of a hat, and were so aggressive and harsh with Class AB crossover distortion and Transient Intermodulation Distortion (TIM) that an entire generation of "East Coast Sound" speakers became duller and duller to compensate.

The return rates eventually became so bad that Scott, Fisher, Sherwood, and many other well-known names were driven out of business, while the hallowed Marantz name was sold to the Tushinsky brothers (who owned the US distribution rights for Sony). I've talked to folks who owned hi-fi shops during this time, and some US-made transistor amps had a failure rate of more than 50% out of the box! Customers aren't exactly impressed with a sales demo that include sparks and a puff of smoke from a brand-new amplifier. (Don't think this is a problem of the bad old days. It wasn't that long ago I was sitting with the editor of a national audio magazine and his $15,000 transistor amplifier expired in a puff of smoke and took his $22,000 speakers along for the ride. I actually saw the tiny flash of light as the woofer voice-coil vaporized from 30 amps of DC offset. True story, folks.)

This was the market opening for Pioneer, Kenwood (Trio in the rest of the world), and Sansui. The Japanese had extensive experience with transistors in cost-sensitive consumer products (the US experience was limited to the military and instrumentation sectors), and they made products that were reliable-enough, looked expensive, had good reviews in the mass-market magazines (a little cash under the table ...), and best of all, had 40 to 50% profit margins for the retailer! The Japanese understood the workings of the US market better than the US manufacturers - after all, as outsiders, they had no preconceptions of how the market should or shouldn't work - they just accepted it as it was, not as it should be.

The well-financed and business-minded Japanese, unlike the American manufacturers, were quite willing to pay substantial advertising costs in expensive glossy magazines like Playboy, wining and dining magazine editors and staff, and paying generous Special Promotional Incentive Fund (SPIF) payments to thousands of salesmen at the end of the day. Back when I worked in retail, SPIF payments that came right out of the cash register of $50 to $100 at the end of the day wasn't at all unusual - and this was back in the early Seventies. For American magazines, product reps, and the local hi-fi store, it was, as they say in the Syndicate, *an offer you cannot refuse.*

As the traditional American manufacturers sank under the tidal wave of Japanese imports, slow progress was made in the development of output transistors, allowing the use of a matched PNP/NPN complementary (or push-pull) output stage with direct-coupling. This removed the worst of the bias reliability problems of the quasi-complementary output stage, but problems with high-frequency instability and thermal runaway still plagued transistor amplifiers, keeping the long-stated goal of "solid-state reliability" as empty as the digital promise of "perfect sound forever."

Things weren't much better in the movie theaters. By now, widespread color television

ownership had cut deeply into the movie-going audience, and most theater owners were not interested in maintaining costly 70mm projection systems with large curved screens. The theaters had been divested from the movie studios by Supreme Court order, and the new independent owners wanted to maximize profits as quickly as possible. That meant bigger popcorn concessions, faster audience turnaround (no more double features where you stay all day if you wanted), smaller screens, a much smaller (and non-union) theatre staff, and a serious technological regression to 35mm film and 1930's-vintage mono optical sound.

We now know the Eastmancolor filmstock of the late Sixties and Seventies was inferior, color-shifting and washing out in less than 20 years. The films that were not transferred to separate frame-registered black-and-white negatives for archiving are now essentially beyond recovery - but frankly, technically, they were crap to begin with, with a reduced 35mm aperture to provide the illusion of widescreen, and low-fi mono optical sound. When you see a really terrible-looking movie or TV show from the Seventies, that's why.

It took more than a decade for high-fidelity stereo sound to return to the new, smaller, multiplex theatres, thanks to the runaway success of the Star Wars movies. (Without Star Wars, it's quite likely the theatre owners would have ignored Dolby Labs and stuck to antique optical-sound mono.) When word finally got out about the poor stability of Eastmancolor, the industry put pressure on Kodak to improve the filmstock, and archivists and historical societies put pressure on the industry to improve storage conditions. Although very few theaters can now exhibit 70mm, a few big-budget pictures are shot in that format, mostly so special effects can be more effective and realistic.

The tape-recorder market was in a state of flux. The introduction of small-signal transistors was a more positive development than in power amplifiers, since high power is not an issue in tape-decks, and the circuit complexity is high ... a situation tailor-made for transistors. Japanese tape recorders, some of high quality (TEAC and Sony), and some not, steadily drove the US-made machines like Ampex, Magnecord, and Viking off the consumer market.

In an unlikely alliance, Nakamichi, Dolby Labs, and Advent co-operated in transforming the Philips Compact Cassette, originally designed as a no-fi portable dictation format, into a near-hifi tape format (similar to MP3s today). In less than 4 years, the new cassette format drove the unreliable 4 and 8-track endless loop systems off the market. The non-technical public had an easy-to-use, hard-to-break stereo tape recorder for the first time. For better or worse, the Compact Cassette is by far the dominant medium for world sales of pre-recorded music, being dirt-cheap, plenty good enough for the mass market, and trivially easy to mass-copy and pirate. The latter is a major advantage for Third World nations that have no intention of paying royalties to obscenely rich Western entertainment corporations - cassettes are still the dominant medium in the Third World, although mass-duplicated CDs and almost-free CD, VCD, and DVD recorders and players are quickly closing the gap.

The Rise from the Ashes
1970-1980

As the Sixties fizzled out into the spreading gray twilight of Asian mass-fi, a tiny ray of light emerged from an unlikely corner of the industry: J. Gordon Holt's typewritten zine, the *Stereophile*. This was a *very* different magazine than the glossy 4-color product you see on every newsstand today. Every pint-sized issue had a grainy black-and-white picture on the cover, and J. Gordon's zany sense of humor was evident in the writing, the goofy cartoons, and the downright funky photos.

This tiny little magazine, with never a single advertisement, was just about the only place

where you'd see serious discussion of the *sonic* merits of the JansZen 130 electrostatic tweeter, the Paoli Mark III, the KLH Nines, the Fulton FMI-80, and a *brand-new* vacuum-tube preamp from a small company in Minneapolis called Audio Research. This was *something else* ... a different set of values was in place here. If you looked hard, you might even find a funky little hole-in-the-wall dealer that actually carried this hard-to-find stuff. In the formative years of high-end, image, style, and fashion counted for nothing, zilch, nada.

The designer-jean, style-over-substance, marketing-uber-alles zeitgeist had to await the ascendency of Ronald Reagan, still some ten years in the future. Remember, these were the dark and war-torn Nixon/Ford years, a different kettle of fish altogether. The counterculture was ferociously alive and well in the early Seventies - this was the time of the Kent State mass murders, antiwar rallies that drew millions to every major city, the release of the Pentagon Papers uncovering a decade of high-level government deception about the Vietnam War, revelations of FBI spying and black ops, and the Watergate dam bursting with the President exposed as the Criminal-In-Chief.

During this unsettled time, J. Gordon Holt played a pivotal role in unearthing the *interesting* things when the American Hi-Fi business had to all appearances entered a state of terminal collapse. Sure enough, here and there, in little workshops all around the land, folks were building strange new products ... vacuum-tube electronics, electrostatic speakers, making direct-to-disc recordings, all kinds of zany items. They made their way to the door of the early *Stereophile*, and the market kept on growing. Slightly less funky dealers started picking them up. More companies appeared. In a few years, a new industry, risen from the ashes of the old, had a name: the High End. (No, Harry Pearson did *not* invent the name High-End. Long before his magazine appeared at the end of the decade, everybody in the industry was already calling it that, so let's put that self-serving little fable to rest.)

When I joined Audionics in 1973, I had a ringside seat watching and participating in the profound changes in speaker design techniques of the early Seventies. The most significant was the re-discovery of Neville Theile's landmark paper first published in Australia in 1963 (and promptly forgotten). Theile, a lead engineer for Australia's Color TV project, had gone on to fully analyze both closed and vented box loudspeakers as 2nd and 4th-order high-pass filters.

No more cut-n-try approximations, no hypercomplex theoretical math filled with mistaken assumptions, just straightforward Butterworth and Chebychev filter functions ... and none of this outdated "M-derived filter" stuff, either. Theile's paper also gives precise methods of measuring fundamental properties of the driver such as Fs (resonance frequency), Qt (damping), and Vas (compliance). With a scope, an oscillator, a voltmeter, a frequency counter, a test box, and a basic hand calculator, you could accurately design a closed or vented box system and get results within a fraction of a dB of the prediction ... a genuine breakthrough in low-frequency design that removed all of the hopeless cut-n-try guesswork of the last 40 years.

What's a little sad is that Theile's paper was ignored for nearly a decade simply because it was published in a little-known Australian journal. It took Robert Ashley of the Audio Engineering Society to pick up Theile's work and also that of Richard Small, who published a very comprehensive summation and extension of Theile's work in his doctoral thesis (as well as the modern near-field method of measuring loudspeakers). All of this material appeared in the AES Journal in 1973-74, and it took the speaker-designing world by storm. Within a matter of months, Theile-Small became the accepted method of designing, prototyping, and measuring closed-box, vented-box, and passive-radiator speakers all over the world.

Small simplified the system so powerfully that all it took was one of the new scientific calculators (the slide rule was beginning to fade away) and a set of nomograms to design accurate bass response. After personal computers were introduced in the early 1980's, the T/S equations became an integral part of every commercially available software package for designing loudspeakers.

Over at KEF in England, Laurie Fincham was extending the analytic techniques pioneered by Theile and Small on the more difficult problem of crossover design. Using the best available HP minicomputer of the day, he was able to acoustically measure the driver using FFT techniques, measure its impedance characteristics using the new T/S techniques, set up a prototype "target function" for the desired crossover filter, and let the computer optimize all of the possible values of crossover elements. In effect, the computer goes through thousands of potential crossover variations and picks the closest approximation to the desired response curve.

Although nearly everyone adopted Theile-Small techniques for bass design (except the transmission-line holdouts), it took ten years longer for computer-based crossover optimization to be widely adopted, due to the high cost of computers and programming. KEF paid more than $100,000 (in 1975 dollars!) for the two-rack-wide PDP-8 DEC system they had; this on top of the custom-built anechoic chamber required by early FFT techniques. The FFT programming was entirely custom-written in FORTRAN for KEF by full-time computer engineers on loan from a local technical college. As you might imagine, this was far beyond what a little company like Audionics could do, and the high-profile American companies of the Seventies, then as now, invested their profits in marketing, not engineering. Serious advances in loudspeaker design was the province of the British in the Seventies. (The Canadians would have their day in the late Eighties and onward, thanks to the government-funded NRDC of Canada.)

KEF, Celestion, and Bowers & Wilkins were pretty much alone in using the target-filter-function technique until the advent of low-cost, powerful PC's with off-the-shelf speaker-design software. Today, the speaker designer mouse-clicks the "optimize crossover" function after measuring the electrical and acoustical response of the driver, choosing the desired crossover topology, and selecting a set of starting values. After the PC models the crossover and graphs the response, you can build the physical crossover, measure the speaker system, and sure enough, it'll be within a small fraction of a dB of the software model. You still have to know what you're doing and how to measure the speaker; the computer won't think for you. But what it has done is level the playing field between the biggest and littlest speaker companies. We all use the same software, and the PC's used by JBL are no different than the one you're using right now - in fact, the computer you're reading this Web page with is far more powerful than KEF's PDP-8 I saw in the mid-Seventies.

The systems-modeling approach perfected in the early Seventies extended to driver design, an even more intractable realm. The BBC was seeking a cone material that would provide exact pair-matching as well as permitting the design of a highly consistent and repeatable monitor speaker. Bextrene, an acetate plastic derived from wood products, first saw use in the KEF B110 driver, which had a starring role in the legendary BBC-designed LS3/5a compact monitor.

(While I was at Audionics, we applied for permission to officially license the LS3/5a design. After 10 long months of British silence, the BBC sent us a very gracious letter that boiled down to "Forget It!" If Audionics had been as business-savvy as one of our competitors, we would have made a second-rate copy, and advertised it as our own brilliant and original design. If

we'd done enough advertising and schmoozing magazine writers, we might have convinced everyone we were first!)

In the late Seventies, the BBC perfected polypropylene cones, which had the significant advantage of not requiring a treatment with doping material, as well as higher efficiency and much flatter response. By a process I still don't understand, the BBC patents were circumvented in less than 3 years, and everybody and their brother started making polypropylene-cone drivers. Even mass-fi rack stereos use polypropylene drivers these days, which tells me that they must be even cheaper than paper to make. However, the BBC was very much on the mark in not using poly drivers any larger than 8 inches; the latest BBC monitor (the successor to the LS3/5a) uses a Dynaudio 5.5" driver with a poly cone, which I feel is the just about the right size for getting the best sound from polypropylene.

Moving on to electronics, the power amps of the late Sixties and early Seventies blew up a lot and sounded pretty nasty. We're not talking classics here, we're talking about junk that should never have been put on the market. The engineers of the early Seventies were still wrestling with problems like maintaining adequate phase margin with real loudspeaker loads, Nyquist feedback stability criteria, staying within the Safe Operating Area for the driver and output stage, and little things like that. Audionics' first amp, the PZ-3, fit right into the picture: loads of feedback, and very low THD distortion measurements. (0.03%, get it?) It measured just fine, but it wasn't too reliable in the real world, with an alarming fondness for shorting out driver transistors, smoking bias resistors, and shooting flames out of the cooling vents (in anticipation of the much larger solid-state melt-down at Three Mile Island).

I remember many days when more of these dogs came back for repair than we shipped out. Some of the amps had circuit boards scorched beyond recognition, and top plates discolored by lines of light-gray soot. We'd replace the circuit board, repaint the top cover, and ship 'em right back out again as "new" product. (Refurbished? What's that? You mean this new amp right here?) Needless to say, the PZ-3 was *not* a big money-maker for Audionics. The only consolation was knowing that all the rest of the high-powered transistor amps were just as bad. (We tested our competition on the bench and they blew up too.)

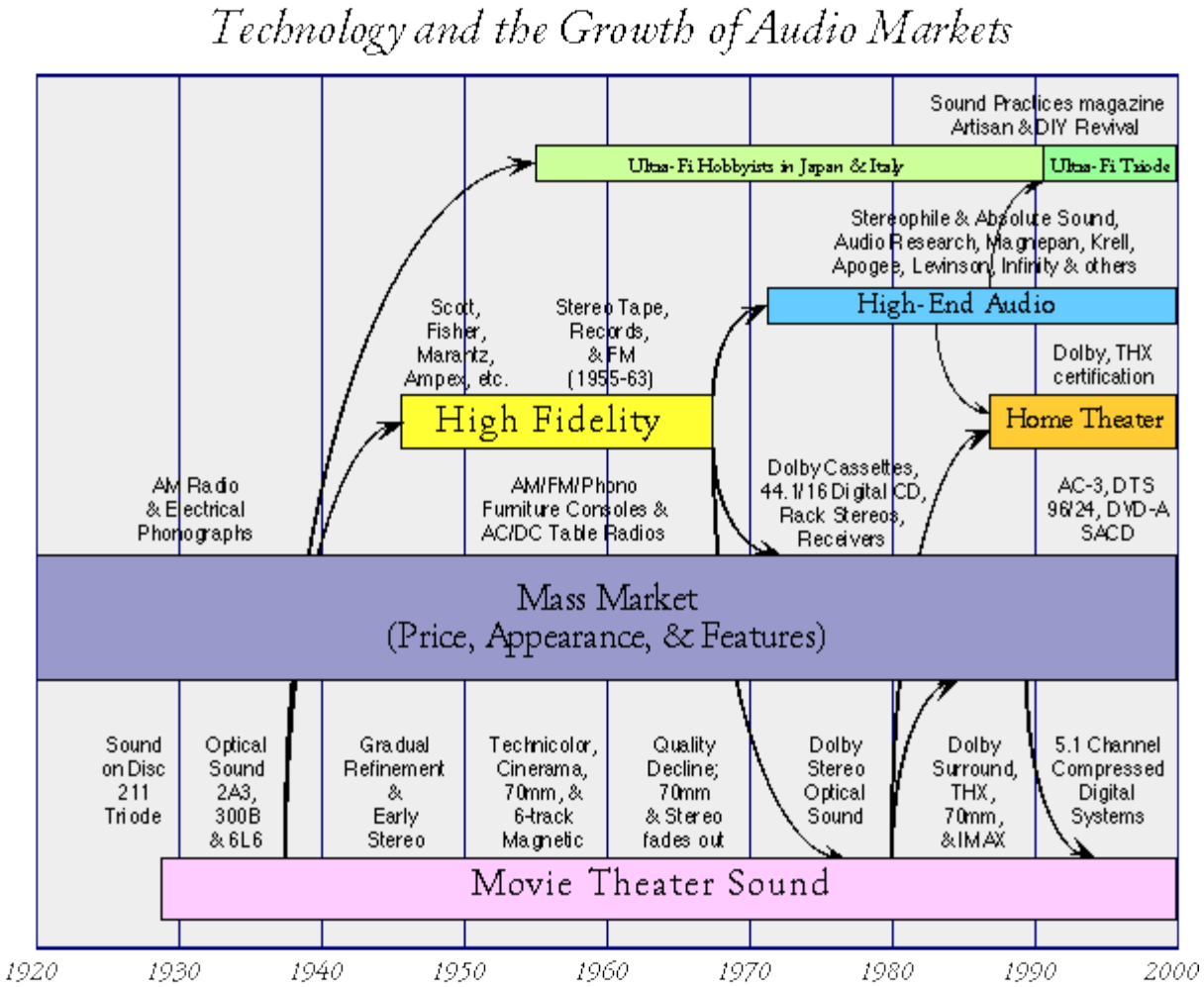
In the mid-Seventies, along came Matti Otala and the discovery of TIM (slewing) distortion. Our Number One engineer (the conservative old-timer who designed the PZ-3) was utterly horrified by Otala's first Audio Engineering Society paper and said it was unscientific bunk (well, his language was stronger than that). Our young Number Two engineer took Matti seriously, let "traditional values" go by the board, and tried a different approach.

Bob Sickler let the distortion rise up to the 0.1% level, by making very large decreases in feedback (feedback dropped from 40-50 dB to 20 dB) and using the most linear complementary-symmetry topology possible. The slew rate and power bandwidth improved by a factor of 10 to 50 times. Best of all, we couldn't break it, even with my speaker simulator load hooked up.

In 1976, Audionics introduced the CC-2, which was the first low-TIM amplifier sold in the US. Sure enough, it sounded much better than the PZ-3, and the failure rate in the field was well under 1%. The reason for both was probably the 200 kHz power bandwidth and an excess phase margin of 60 degrees, both quite unusual at the time. Although I rarely listen to my CC-2 these days, it's still not a bad transistor amp; by now, though, nearly all transistor amps use the same design principles as the CC-2. Matti's paper had such a profound impact on the solid-state design community that nearly all high-end engineers got on board ... besides, it's hard to argue with better reliability, which a high slew rate and adequate phase margin certainly provide. Everyone loves reliability (well, I have to make an exception for software

companies, but I digress).

As the high end market expanded in the mid-Seventies, Harry Pearson's "The Abso!ute Sound" magazine made its first appearance. HP's approach was more subjective than Holt's, and he was attracted to more unusual products than Holt. I wasn't a big reader or follower of HP, since he was attracted to things that left me cold, like the Dahlquist DQ-10, the big big Infinity panels, and the ever-updated galaxy of Magneplanar and Audio Research products. Still, despite my personal feelings, I must credit HP with playing an absolutely crucial role in blowing the whistle on the truly appalling sound of the first CD's, and in kindling the flames of the tube revival. Also, HP provided a continuity that could easily have been lost when J. Gordon Holt sold Stereophile to its new owners. (The "Establishment" Stereophile you see today bears *no* resemblance in style or content to the sassy, funny, and contrarian earlier magazine.)



I still remember the massive PR blitz (similar to the Windows95 onslaught) pushing the first CD's and their players. I didn't take the claim of "Perfect Sound Forever" too seriously, but I really *did* expect that digital sound would be a significant advance for the entire industry. (In extenuation, I was an AES member at the time.) After all, LP's have serious problems with end-of-side distortion, noise buildup, guessing the correct VTA adjustment, etc., and tape has its *own* set of troubles with scrape flutter, IM distortion, setting bias and EQ for the exact tape formulation, Dolby mistracking, etc. etc. Digital sidesteps all these problems, and has noise and distortion approaching that of an op-amp ... hundreds of times better than any LP or tape medium. In principle at least, it should sound as transparent as a good amplifier. Little did I know.

As it turned out, the designer of the CC-2, Bob Sickler, went out and bought one of the very first players, the Sony CDP-101. His roommate was a professional musician for the Portland Symphony, so when they *both* sang the praises of the new medium, I was expecting my first experience with digital-in-the-home to be something like hearing a well-done mastertape, or even a live mike-feed straight from the console. After all, both them had good taste in music, and I knew that the digital process was almost distortionless compared to any other medium. It had to be good, right?

My friends put on a all-digital DGG classical disc and all I heard from the big TAD studio monitors was screech, screech, screech. The massed violins were far worse than any Columbia LP I'd ever heard ... they actually sounded like carbide saws cutting into two by fours, and I heard tearing and ripping sounds in the loud passages. Gross over-the-top clipping distortion on a so-called "audiophile" recording. Unbelievable. The quiet passages were dead silent ... actually, like a switch turned off ... but any sensation of space, of stereophonic dimension, and of acoustic presence was totally absent. The start-stop reverberation sounded as flat as a paper moon and just as fake. I was speechless ... this was the most repellent sound I had heard in many years, and I knew it wasn't the fault of their hi-fi system, which was pretty good.

My Audionics friends were grinning the whole time and saying, "Isn't it so *clear!* There's no noise and clicks at all!" I was silently thinking "Is *this* the future of audio!?" So I simultaneously experienced both bitter disappointment and astonishment that my friends were having such a radically different sonic experience. And my CD-loving friends weren't headbanging yahoos; heck, one played violin in the Portland Symphony and the other had designed a first-rate amplifier, the best of its day. But they loved those first DGG discs and I was nothing less than appalled.

That whole experience really opened my eyes - and ears. I realized that people *really do* hear things in quite different ways ... my friends thought the Sony CDP-101 and the shiny little coasters were just terrific, and I thought they sounded awful! After that, I started taking the reviews in *any* magazine a *whole lot* less seriously. After all, how was I to know the reviewer was hearing same things that I did?

This experience gave me an unpleasant premonition about the future of the high-end industry. The exhibitors could only play LP's for so long at the CES before they gave into the tide of weirdly artificial CD's. What would that mean for product design in speakers and amplifiers? For one thing, forget about super-performance tweeters that went beyond 20kHz; that was dead forever with the ferocious brickwall filter that had to descend 96dB (the entire dynamic range of the CD) in the tiny frequency range of 20 to 22 kHz. And the sonics themselves? How would even the most clever engineers get around that?

Of course, little did I suspect that "tweaking" would become the relentless obsession of many audiophiles and reviewers, and develop into an entire sub-industry of its own ... the first funny-looking Fulton speaker cable has only been on the market for a few months. I was still in the Seventies mind-set that you built audio equipment to sound good, and then you listened to it until it was time to build something new, and hopefully better.

I left Audionics in 1979, went down the street, and joined Tektronix. No more big frog in a little pond, but the time spent with the Spectrum Analyzer business unit was an education not available in any sector of the audio business. MIL-SPEC and consumer-grade are two very different ways to build products. During my 9 years at Tektronix, I peeked in on the audio world from time to time. I remember a brief flurry of interest created by the Quad 405 quasi-feedforward amp, with different exotic mixed feedback schemes appearing in every other issue

of the Audio Engineering Society Journal. For a while there, it looked like the old-time high-feedback engineers and the new boys on the block could have it all: *zero* distortion, very wide power bandwidth, ultra-high slew rates, a simple output stage that didn't require any bias tweaks, and the complete elimination of crossover distortion!

Unfortunately, once you hooked these miracle amps up to real loudspeakers, the balance equations evaporated. (Isn't that just like speakers ... they're always screwing up the latest "wonder amp") As a result, none of this intense theoretical activity resulted in any lasting sonic breakthroughs, except to once again point the finger at loudspeakers.

The Fashion-Magazine Gatekeepers Take Over 1980-1990

From the perspective of an outsider, the Eighties were not the best decade for audio. As CD's wiped out LP's, many high-end consumers gradually forgot what good sound was like, and looked for guidance from the Big Two audio magazines. As these publications grew in circulation and advertising revenue, they tightened their grip on the industry, becoming gatekeepers that told faithful readers and chains of audio-boutiques which brands were "in" and which was "out", following the model of the fashion industry.

After Gordon Holt sold Stereophile magazine at the end of the Seventies, the policy did a swift 180-degree turn from "No Advertising" to only reviewing products that *were* advertised in the magazine - and had a minimum of six dealers, making for a slick little Catch-22 for new manufacturers trying to break into the market. You either had deep (corporate) pockets and entered the market with a big splash, or could forget about any reviews in the magazine that now saw itself as the industry's gateekeeper. Gotta keep the riffraff out, doncha know.

In a few years, things reached the point where high-end audio was no longer about sound, but perceived status, with high-profile reviewers passing out awards to the "inner circle" of manufacturers. Dealers had little choice but go along and get along; customers came in to the store clutching a dog-eared copy of the magazine, and by golly, they wanted that "Component of the Year" right now. At a discount. Especially if the review said it was *much* better than last month's favorite.

At a time when the Japanese magazine "MJ" was seriously writing about the sonics of Western Electric 300B's, Osram PX25's, RCA 845's, and GEC KT66's, the Big Two American magazines were rhapsodizing about this month's favorite $7000 DAC and $3000 speaker cables ... all supported by 4-color ads costing the manufacturer several thousand dollars per issue. The cheapskates were amused and entertained by the "tweaks" section and the letters column while the High Rollers got the color picture on the cover, the lead article, and most of the reviews. It was the Age of Reagan, after all. The stock market was rising by the day, hostile takeovers were reshuffling the map of corporate America, and Greed Was Good.

One reason audio magazines of the Eighties never compared Western Electric and Golden Age tube equipment to modern high-end was a simple result of the business ethic of the times:

Nobody ever paid Advertising Money for something that was 40 years old ... so it was off the radar screen entirely. Didn't exist. Hey, it's old, how could it be any good? Since Americans were taught by the magazines that old-timey stuff was junk anyway, guess where it ended up? The Akihabara district in Tokyo, to be sold to wealthy Japanese who sold Japanese mass-market electronics - to gullible Americans who believed every word in the trendy US audio-fashion magazines.

Big-name equipment reviewers came up with their own wacko vocabulary for aspects of sound ... words having nothing to do with sound or music, "bleached," "chocolate," "white," and others became part of audiophile jargon. This trained the audiophile to zero in on abstract sound elements, instead of the simple pleasure of listening to music. The magazines eventually came out with their own CD's complete with listening instructions for each track ... truly *"Hi-Fi for Dummies,"* marking the degeneration of High Fidelity into a fashion-lifestyle statement.

The reader might think this is a pretty harsh assessment of an entire decade, but seriously, what has endured? Are there *any* classics from this time? Would *you* want a 1986 "state of the art" cable? A "statement" 1988 CD player? A 200-lb transistor amplifier chock-full of silicon goodness?

I didn't think so. Nothing goes stale faster than yesterday's hype. Nothing exemplifies that better than the magazines themselves; it's a thrill to read Fifties enthusiast magazines, J. Gordon Holt's Stereophile of the early Seventies, or practically any issue of Audio Amateur. But seriously, who wants to read a 1985 issue of Stereophile or Absolute Sound? C'mon, anyone?

Two good things came out of the Eighties: slow but steady improvement in speaker-driver technology and Walt Jung's important article about capacitor sonics in Audio Amateur. This article put "passive" components under the microscope for the first time, and surprise, they turned out to be a major source of subjective coloration.

Capacitors have easily measured differences in Dielectric Absorption (DA) and Dissipation Factor (DF). Teflon, polypropylene, and polycarbonate are best, and electrolytic, ceramics, and solid tantalums are the worst. And dielectrics (insulators) are everywhere, in circuit board substrates, wire insulation, anywhere two conductors must be electrically isolated. As with Matti Otala's TIM article 5 years before, there was a lot of resistance from the old-timers, but Walt Jung's DA and DF measurements were easily made and correlated well with what you could hear. In addition, people were finding out with digital sound that measurements right at the limit of detection were just as important as traditional THD and noise measurements.

This opened the door to examining discovering subtle weaknesses not seen before: caps are microphonic, and can self-excite and "sing" at resonant frequencies. Metallized-foil caps sound different than solid foil caps. Even solid-state electronics can be affected by vibration thanks to circuit board flexing and low-level microphonics in the polarized and charged electrolytic power-supply caps. Resistors can have voltage coefficients, and low-level point-contact rectification where the dissimilar metals meet. Insulation on wires in transformers and inductors can have poor DA and DF characteristics, and the process of winding the wire induces stress cracks where oxygen enters the wire. Low-level, hard to measure, but plainly audible on a good system.

For speaker and electronics designers, this adds another layer of fine-tuning ... but also another degree of freedom. I was surprised when I designed the Ariel that changing the tweeter caps to a different brand was subjectively equal to about 0.5 to 1.0 dB of equalization. Back in the Seventies, I used junkbox Mylar-films, along with everyone else, and equalized the speaker around them. These days, it's a choice between solid-foil Polypropylene, exotic Silver/Oil, or new-production Teflon caps if you want the best sound. Yes, they may cost as much as the tweeter itself, and it'll be worth it - and a lot more cost-effective than messing with cables.

The biggest difference between pre- and post-Eighties design is the awareness that "passive"

parts may actually have more coloration than active circuitry. A pre-Eighties circuit will toss "nonpolar" electrolytics all through the design ... take a good look at a Revox A77 or Dynaco PAT-4 schematic if you want to see a lot of coupling caps in the signal path. It wasn't until the mid Eighties the idea arose that **every single part** in the signal path had to be examined for sonic degradation, not just transistors and tubes. The "Progressive Optimization Of Generic Electronics" (POOGE) concept goes back to Audio Amateur's series of articles about improving mid-fi amplifiers and CD players by replacing bad parts with good ones; it can be applied with even more success to a new design, and became standard practice in the industry.

The Thermionic Revival Meeting
or, Back to the Future

Thousands of engineers, designers, and hi-fi fans were ready for a return to good sound after a decade of more and more "accurate" speakers, power amps, and CD players. The crusade for magazine-defined "accuracy" had reached the point where reproduced sound was spectacular but also becoming bizarre and unreal.

In 1989, Ed Dell, publisher of Audio Amateur, took a chance on a new magazine devoted strictly to vacuum tube amplifiers. "Glass Audio" had three strikes against it: vacuum tube manufacturers were disappearing, most hi-fi retailers refused to carry tube equipment, and the magazine catered to the hobbyist market, which was also fading away. Yet a year later the magazine grew to twice its original size, and the readership kept growing with each new issue. What was going on here?

A little anecdote might illustrate what was happening on a larger scale. At the time I glanced at the first promotional issue of Glass Audio, I was also working on an advanced 200 watt MOSFET amplifier with two friends from Tektronix. This amp represented the pinnacle of the high-end art: fully differential, all-cascode, all-Class-A, zero-TIM, 200V/microsecond, fully regulated, and 120 watts/channel. The same month, I went to the second Oregon Triode Society meeting, and one of the members brought a rusty old Dynaco Stereo 70 that first saw the light of day when Dwight D. Eisenhower was President. The sum total of his "tweaks" was to convert the EL34's to triode (cut and tape two wires), and replace two coupling caps. About 2 hours with a soldering iron. We're not talking aerospace engineering here.

The OTS guy turned it on, and we compared the Stereo 70 to everything in the dealer's showroom. It was plainly superior not only to any transistor amp in there, it wiped out the latest $3000 Audio Research all-tube confection that had received a glowing review in the latest Stereophile. Say hello to humble, and good-bye to price, power, and prestige. (That dealer did *not* invite the OTS back - gee, wonder why? Buncha troublemakers if you ask me.)

If you stay in audio long enough, that kind of experience can make you do some *deep thinking* about cherished assumptions. I set aside the transistor project, stopped laughing at the "tube nuts" and subscribed to Glass Audio (Vol. 1, Issue 0). Two years later, I reviewed the Herb Reichert Silver 300B and the Audio Note Ongaku for Positive Feedback (on the newly-designed Ariels).

As the speaker designer, I felt I knew my speakers inside and out. Or so I thought. The Ariels were transformed from a pleasant speaker to near-electrostatic realism and "you-are-there" quality. All from changing an amplifier! David Robinson later called this my "Road to Damascus" experience. That ended any idea that amps were pretty much all the same, or if they weren't, mainstream high-end gear was pretty close to perfect. I was surprised to discover that speakers were better than I thought, and that amps had a long long way to go.

As articles from Japanese and French magazines appeared in Sound Practices, Glass Audio, and Vacuum Tube Valley, the notion of craft, or "artisan" audio began to emerge. People started to design and build exotic amplifiers that cost thousands of dollars in parts alone, and then told others about their experiences in new magazines, the Internet, and regional vacuum-tube audio fairs. The subversive notion grew that quality was something you built, not something you bought.

As people built more, it became apparent that mainstream prices were grossly inflated relative to parts cost ... the transistors in a $15,000 high-end amp cost less than a hundred dollars, while fancy metalwork, 4-color ads, and a dealer network add zero to the sound. On the other hand, hand-made power triodes, point-to-point chassis wiring, and custom-wound transformers are obviously expensive and labor-intensive ... and the difference from mainstream high-end to triode are obvious to the most casual listener. Oddly enough, many audiophiles are relatively deaf to the experience, but non-audiophiles can hear it right away.

I've had audiophile friends play "Planet Drum", "Jazz at the Pawnshop" or the latest Stereophile test CD on a superlative amplifier like the Ongaku and just not "get it." I would play ravishingly beautiful music that would take me close to tears and my guests would just look bored, or start talking over the music. That's when I realized there really is a difference between listening for certain audiophile sound effects and getting swept up in the music. Obviously, musical tastes differ, but there's listening **to** music and listening **for** sound effects.

The home-theater boom of the Nineties underlines this. These gadgets don't play music at all; they measure well and all that, but music? It's like there's a hidden MP3 processor in there, stripping away 90% of the content, leaving behind a music-like shell with nothing in it. I have no clue how the home-theater people do it, but music has a real struggle getting through these things. Dialog, sound effects, car crashes, phaser blasts, you bet. Music? Nope. Can we interest you in a personal MP3 player?

Like ancient Gaul, the audio market has split into three parts: home-theater (the life-support system for just about every dealer), high-end (for few remaining true believers in the review magazines), and last but certainly least in terms of market share, equipment optimized for music playback.

But thank goodness it's there, otherwise we wouldn't have any High Fidelity at all. And somebody must be paying attention, since we finally have the gift of digital done the way it should have been in the first place, the competing Sony DSD and DVD-A systems. How the same companies that designed the mid-fi 44.1/16 PCM Red Book standard came up with not one, but two genuinely high quality digital systems is a mystery I don't understand (although the expiration of the original Sony/Philips patents might have a lot to do with it).

What's interesting about DSD and DVD-A is that it exposes the "accuracy" claim of 44.1/16 digital as the fraud it was all along. The new mediums sound very close to top-quality analog mastertape or direct-disc sources, while the exact same material on a top-flight CD player sounds flat, artificial, canned, the exact words that were used to describe it 20 years ago.

Play some music from SACD, DVD-A, LP, or open-reel tape on a vacuum-tube system to an audiophile used to solid-state, and they are usually startled by just how "Stereo" and three-dimensional everything sounds. Well, why do you think "Stereophonic Sound" made such a big impact in the Fifties? It was all-analog, all-tube sound, and the difference between "Stereophonic" and mono was astonishing. We are very lucky to have to have both triodes and SACD/DVD-A make their joint appearance at the turn of the century. Rather than a bunch of old-timers grousing about how great things sounded in the Golden Age, all you have to do is

build a simple triode system, get some efficient speakers, and **show** friends what Stereophonic High Fidelity is all about. If you don't want to build, well-restored Golden Age equipment is satisfying and a heck of a good deal.

Don't know where to look? For building, try the Tube DIY site at Audio Asylum. Want to own an American classic? Try Vacuum Tube Valley for starters (avoid eBay!).

The New Millenium

Looking back, it's interesting how the 1930's, the 50's, the 70's, and the 90's were periods of rapid innovation and change, while the "out" decades have been times of backsliding, mass-fi, and technical regression. Where next? The fizz and argumentation of the first wave of triode mania has come and gone, taking many of the early magazines with it.

Home theater continues to make inroads on the remnants of the mainstream High End business. Transferring the prestige game from 2 channels to 5 ... or 6 ... or 7 channels is pretty simple, especially if you can persuade the client to build a "media room" to show off all the fancy, soon-to-be-obsoleted gear. What's funny are the short time horizons of the home theater crowd; it was only a few years ago they started buying expensive system controllers that were all digital. All digital at 44.1 or 48 kHz, of course.

What about higher-fidelity mediums like DVD-A 192/24 or DSD? Ooopsie! Thanks to the paranoia of Hollywood executives, a standard for transmitting DVD-A or DSD from player to receiver or DAC has been a long time in coming - many CD and DVD players still downsample to the legacy Red Book 44.1 or Dolby Digital 48 standard before they transmit a digital signal to the outside world. (Pioneer is a welcome exception here.)

The business model for vacuum tube audio is still being developed. The Japanese market is a pale shadow of the glory days in the early Nineties, so sales must go into the ever-cautious American market and the Chinese portions of the Asian market. The Internet is making a difference; although individual newsgroups, bulletin boards and forums are regularly disrupted and eventually destroyed by anonymous trolls, quieter and more civilized groups promptly appear to replace them. The Internet is a big place, after all. The biggest opportunity are people who love music, then discover that home theater or mainstream high-end are not for them.

This is where well publicized regional hifi shows can make a real difference. Another idea would be adult-education classes through local community colleges, similar to existing classes in Wine Appreciation or Gourmet Cooking. There's no reason that music-appreciation classes in Quality Audio couldn't be offered in the same way, with advanced classes offering hands-on instruction in kit-building. All you have to do is connect music lovers with genuine high fidelity, show them it doesn't have to cost absurd prices or turn the home into an engineering lab, and they'll figure out the rest.

The Library

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