Conrad Johnson

In the mid-seventies, two economists, friends and serious audiophiles - Bill Conrad and Lew Johnson - were highly dissatisfied with commercially available audio equipment. Both felt their classic tube systems sounded better than new transistor equipment. They were also perplexed by the sonic differences between the electronics in their audio systems. What made these two classic tube systems sound so different? Could the virtues of each be somehow combined? Not content to merely speculate on such issues, Conrad and Johnson decided to systematically investigate by developing a preamplifier, confident that the end result would be an important improvement in their own systems.

They spent the next 18 months educating themselves in electronics, developing a research methodology, and building and refining their preamplifier. The results were so impressive that it was decided to market the preamplifier. That original conrad-johnson preamplifier was immediately recognized as a state of the art contender and catapulted Conrad and Johnson into the audio industry in 1977. In the succeeding years, conrad-johnson has grown to become one of the most respected brands in audio, with a wide range of products distributed in more than three dozen countries.

The most important legacy of **conrad-johnson design's** humble beginnings is the basic methodology that took shape in the course of the development of that first preamplifier. This methodology has enabled Conrad and Johnson to develop new and improved products that have consistently been ranked among the most musically satisfying. No other manufacturer has so consistently received such high praise for its products.

Conrad-Johnson believes the purpose of a high fidelity audio system is to bring the enjoyment of live music into the customer's living room. Further, we are committed to offering solid, reliable products at prices that represent honest value. In short, conrad-johnson's design objectives are: **Musical Accuracy, Quality,** and **Value**.

Our Design Philosophy

In the pursuit of these objectives, we have learned the importance of an elementary proposition. Best results are achieved by the application of highest quality parts to simple circuits. Why? Because every component part imposes its own colorations on the sound of the circuit - simple circuits with high quality parts will sound better. Also, simple circuits tend to be more reliable than over complicated circuits.

Simple Circuits + Quality Parts =

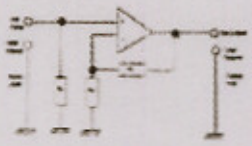
Musical Accuracy + Quality + Value

Circuit Considerations

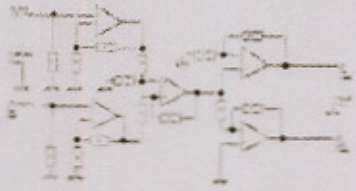
Keep It Simple

It is worth repeating: best results are often achieved by the application of the highest qulaity parts to simple circuits. Circuit design should be as simple, and straightforward as possible, subject to achieving the criteria listed above. Our experience has been that this approach will yield the most musically satisfying designs, as well as the most reliable. In audio, often times, LESS is MORE.

Here's a test: which circuit design approach sticks to the mandate to *KEEP IT SIMPLE?*:



Single-ended circuit



Balanced Circuit

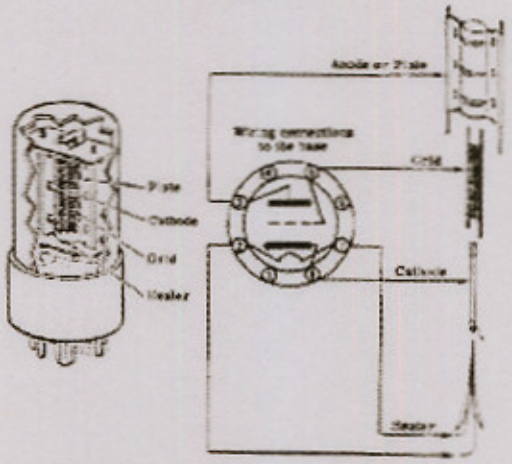
Choose The Right Device for the Job:

Why are people still using vacuum tube preamplifiers and power amplifiers? After all, vacuum tube products typically cost more and the tubes must eventually be replaced. Vacuum-tube products continue to sell for one basic reason: they sound better. This is not to say that every tube component sounds better than every transistor component. Only that a well-designed tube product will sound better than an equally well designed transistor product.

Tubes

Vacuum tubes have two important advantages as audio devices. First, they are inherently more linear (have lower distortion) than transistors. This is a direct consequence of the higher voltages at which vacuum tubes operate. Because of the lower inherent distortion, tube circuits can be executed with less feedback and fewer devices (simpler circuits), resulting in much better musicality than circuits which require massive amounts of negative feedback to reduce distortion to acceptable levels.

The second advantage of vacuum tubes is that their distortion is almost exclusively 2nd order. The 2nd order distortion product of a musical tone is the same tone an octave higher. This is a highly musical distortion, making the



Tubes sound great, and deliver full, rich sound.

reproduced sound slightly richer in harmonic overtones than the original. This property is shared by field-effect transistors (FETs) as well. Bipolar transistors, on the other hand, produce significant levels of odd-order harmonics when used as voltage amplifiers. These odd-order distortion products are musically unrelated to the original tone. They are intrusive and detract from the music.

The distortion characteristics of the devices are particularly critical for input voltage amplification stages, which dominate the distortion character of the circuit. Ranking input devices for quality of music reproduction, we have:

- 1. vacuum-tubes: low distortion, musical distortion products
- 2. fets: higher distortion, musical distortion products
- 3. bipolar transistors: higher distortion, dissonant distortion

Ranking Devices – For Input (Voltage) Amplifiers: tube>fet>bi-polar transistor

The distortion characteristics of an audio circuit are dominated by the voltage gain stages, where clearly, tubes and fets outperform bi-polar transistors. For output stages (especially in power amplifiers), however, the main consideration is achieving a low output impedance, and are in which bi-polar transistors excel.

Keep Output Impedance Low

The output impedance of a device is just a measure of the degree to which that device resists or impedes the delivery of current to the subsequent stage. Low output impedance is important for both preamps and power amps. The output impedance of a preamp limits the current that can be delivered into the capacitive load of interconnect cables, forming a filter which rolls off high frequencies. The higher the output impedance of the preamp, the less high frequency information will arrive at the amplifier. This is the fatal flaw in "passive" line stages, where the high and variable impedance of the level controls causes frequency response to vary with the volume and balance control settings.

In amplifiers, the output impedance limits the current delivered to loudspeakers on transients. The use of "ultralinear" output stages and modest amounts of negative feedback (10-12 dB) achieve a low output impedance for tube amplifiers. One of the important limitations of nearly all "single ended triode" power amplifiers is that they have an extremely high output impedance (usually 4 to 8 ohms). Such a high output impedance typically results in highly muted transient response and severe frequency response anomalies (10 to 20 dB variations within the audio range are common) when connected to a loudspeaker. For transistor amplifiers, the output impedance is determined by the type and number of output devices. Bi-polar transistor output stages offer the lowest impedance.

ART Technology

The Anniversary Reference Triode Preamplifier (ART) is an excellent example of adjusting circuit design to achieve a low output impedance. The design brief for the ART was to reduce the circuit to its simplest configuration (*KISS*). That meant a single triode gain stage. But triode tubes have a high output impedance, and therefore cannot drive long interconnect cables. In the ART a low output impedance is achieved by creating a high-current "super triode" by paralleling ten sections of miniature twin-triodes. This novel approach achieves a low output impedance without resorting to added circuitry. The resulting purity of sound and remarkable time coherence has won the ART (and its siblings – the Premier 16LS and Premier 17LS) accolades and awards from reviewers, industry insiders, and customers.

Some of the awards for the ART's composite triode circuit approach.

Minimize Negative Feedback

Negative feedback reduces the distortion of continuous sine waves, increases bandwidth, and minimizes the effect of defects in the component parts. For this reason, high amounts of negative feedback are resorted to by most electronics engineers as a cheap fix for poor parts quality, and for careless circuit design. Unfortunately, negative feedback introduces aberrations in the transient response, blurring transients and obscuring ambient detail. Highly linear, wide-band circuits require very little, if any, feedback to yield excellent performance, but they will require the use of the highest quality parts if little feedback is used. In fact, all conrad-johnson preamps are zero feedback designs, and all of our amplifiers use minimal feedback (10-12dB compared to many amps using up to 1000 times as much- 72dB).

Negative feedback blurs transients and diminishes the sense of ambiance.

Use Discrete Circuits

A common cost-saving approach to audio circuit design is the extensive use of integrated circuits. These ICs are typically an entire class AB amplifier of a dozen or more transistors with all associated resistors and capacitors contained on a single silicon chip the size of a small transistor. These miracles of modern technology are the heart and soul of today's computer equipment. From an audio point of view, these circuits are composed of the lowest possible quality resistors and capacitors (micro size is the only design consideration) in a circuit with typically 100 dB or more of negative feedback. The sonic results are predictably poor.

IC op amps are everything we want to avoid in circuit design in one convenient package.

The audio circuits and related power supplies in conrad-johnson brand products are always discrete circuits - we use no ICs for these circuits.

Pay Attention to the Power Supplies

The DC power supplies for any audio circuit are part of the audio signal path. Any deviation from the design voltage will be reflected in the final audio

output. This makes power supply design every bit as important as the audio circuit itself.

Power Supplies

The regulated power supplies in conrad-johnson products are discrete circuits, designed to maintain a rock solid DC voltage, even when delivering current for high-speed transients. These supplies use polypropylene and polystyrene capacitors exclusively, there are no electrolytic capacitors in the regulated DC power supplies. Compare a typical conrad-johnson regulated power supply to the common three-pin regulator found in so many audio products today:

3-pin regulator

conrad-johnson regulated power supply

Power supply design is especially important in determining the ability of a power amplifier to punch out musical transients. Loudspeakers are typically reactive loads (their impedance varies with the frequency of the audio signal), some dropping as low as 1 ohm. With real world speakers, dynamics are more dependent on the ability of an amplifier to deliver current than on its power rating. Any drop in the power supply voltage in response to a transient signal will soften that transient. The ability to deliver current on such transients depends on the size and quality of the main DC storage capacitance, and on the quality of the main power transformer.

The main capacitance bank of a power amplifier forms a DC voltage reservoir that smoothes the effect of a transient on the supply voltage. The more the

capacitance, the less the effect of the transient, just as dropping a pebble in the center of a lake will cause less ripple than dropping the same pebble in the center of a pail of water. Additionally, the quality of the capacitance used in the power supply matters, just as it does in the audio circuits. See the section on capacitors below.

The power supply and audio circuit are like two blades of a scissors – both must be sharp for the scissors to cut clean

The DC voltage is ultimately supplied through a rectifier by the AC mains transformer. The current draw on the transformer fluctuates with the music. Increases in current cause a drop in the voltage the transformer can supply. Typical low-cost transformers will "sag" by 40% at full power. The larger, more costly transformers used by conrad-johnson reduce this voltage sag to about 5%.

All conrad-johnson power amplifiers are designed with "stiff" main power supplies (supplies that do not drop much in voltage under load). This is accomplished by the use of oversized power transformers and massive capacitance banks. Amplifiers with soft power supplies will boast of high dynamic headroom (3 to 6 dB), but will lack "punch" on demanding musical passages. These headroom numbers are really a reflection of low quality power supplies. An amplifier with a perfectly solid power supply will have 0 dB of dynamic headroom.

Quality Parts

The musical performance of any audio circuit is critically dependent on the component parts of which it is made. Every piece, whether active or passive - even wire - colors the sound. We are acutely aware of the importance of parts selection. Conrad-Johnson sets the standard of parts quality for the audio industry.

Capacitors

Capacitors are especially critical to the sonic performance of audio circuits. A transient audio signal abruptly charges and then discharges the capacitors in its path. Unfortunately, the capacitor has a tendency to seek its prior state of charge - a sort of sonic memory. This property is called dielectric absorption (DA) and is measured as a percentage of the original charge that is "remembered" after the capacitor has been discharged. The sonic effect of this memory is like a ghost signal on your TV screen. The result is blurring of transients and obscuring of ambience information. The clarity of transients and the precision of imaging can be seriously degraded by inferior capacitors.

2.0 uF capacitors – CJD vs. electrolytic

Not satisfied with available capacitors, conrad-johnson has worked closely with a manufacturer to create special "CJD" capacitors in polystyrene and

polypropylene, with DA as low as 4/10ths of a percent of that typical of electrolytic capacitors (about 250 times better than an electrolytic, and roughly that much more costly). The lower DA of these CJD capacitors results in much improved clarity of transients and precision of imaging. The photo illustrates the difference in size between a CJD polystyrene capacitor, and an electrolytic of the same capacitance. Overall scale is indicated by the quarter in the photo.

Resistors

Resistors have the critical role of establishing the operating points for the active devices in a circuit, determining overall gain, feedback ratios, etc., and also setting frequency response characteristics in filters (eg. RIAA response curve). The tolerance of a resistor (the maximum deviation from its nominal value) determines the precision with which these circuit characteristics are set. Typical carbon-composition resistors have +/- 10% tolerance, carbon-film +/- 5%, and metal film 1 or 2%. In addition to offering closer tolerances, the metal film resistors are more stable in value with variations in temperature, and over time.

Resistors range in price from a fraction of a cent for some carbon film types to several dollars each for metal foil. Guess which sound better.

Resistors are also, unavoidably, a noise source. The higher quality metal film resistors contribute less noise than carbon composition resistors. In the audio circuits, and in the power supply regulators of the PV/MV and PF/MF series of products, conrad-johnson uses high quality metal film resistors exclusively. These resistors are a special type constructed of tin-oxide deposited on a glass rod. While expensive (roughly ten times the cost of carbon-film types), these resistors provide important sonic benefits.

The Premier products use an even more exotic resistor type, in which the resistive element is metal foil, laser trimmed to precise resistance values. Unfortunately, the extremely high cost of these high-tech resistors necessarily limits their use to our Premier product range. It is worth noting that these

costly parts are to be found in very few of even the most expensive products from competing manufacturers.

Transformers

All audio amplification components require dc power supplies to operate. In nearly all cases, these dc voltages are obtained by rectifying an ac voltage which in turn comes from adjusting the ac mains power (from your ac wall outlet) up or down through a power transformer. The power transfomer(s) must be carefully designed to avoid excessive magnetic fields (especially in preamplifiers, where the fields can easily result in noise in the form of hum) and must be capable of delivering sufficient current to meet the transient demands of the circuit (especially for power amplifiers, where the current demands can be quite substantial).

In conrad-johnson products, power transformers are specified to handle considerably more current than they will be called upon to deliver. In the case of power amps, the transformers are often large enough that others might well use them in amplifiers of roughly twice the power rating. Also, particular attention is paid in transformer design to minimize and contain magnetic fields.

In a tube power amplifier, there is also an output transformer required. This transformer matches the output impedance of the tubes to the impedance of the speaker, to allow for efficient transfer of power. Complex considerations are involved in the design of an output transformer. Bass extension, high frequency extension, transient response, power output, and distortion are all directly influenced by output transformer design. One fairly obvious consideration is that the transformer must be big enough for the job. Visual inspection will show that conrad-johnson typically specifies rather heavier output transformers than many of our competitors. When it comes to bass response, there is no substitute for a sufficiently large transformer core.

Conrad-Johnson's Transpectral output transformers offer bandwidth up to ten times more than conventional designs

The more subtle aspects of the art of transformer design are not readily visible, since they relate to the selection of materials and the patterns for interleaving and connecting the internal windings. By carefully controlling these factors, we have been able to design output transformers with greatly extended small-signal response (to 500 kHz as used in our flagship Premier Eight). These *Transpectral* output transformers are used in the Premier 12 and MV60 tube power amplifiers.

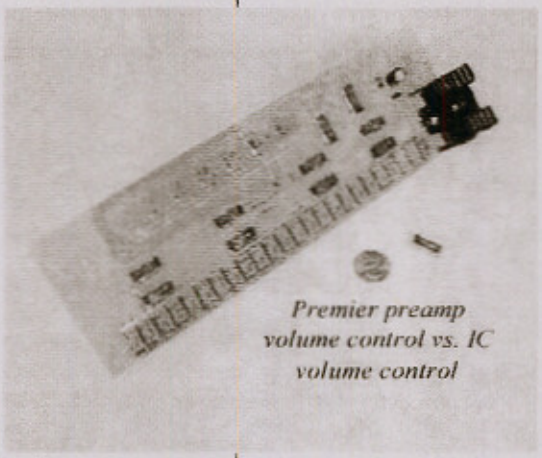
Selectors

If a component is to continue to perform properly for years to come, the selectors and controls must be of top quality so that they continue to make clean, reliable connections. Conrad-Johnson uses industrial quality rotary selectors rated for 1/2 million cycles. Relay switches, when used in the signal path, are gas filled and gold plated to avoid corrosion.

Level Controls

The quality of the level control can limit the performance of even the finest line-stage preamplifier. Conrad-Johnson uses three different level control designs. For the top of the range Premier products, we use a stepped attenuator with 100 steps of approximately .7 dB per step. The steps are selected by a microprocessor that controls an array of relays (or fet switches in the case of the PV14L). This type of level control offers precision tracking over the entire range of steps, exact repeatability in level setting and can be readily operated by remote control. It also boasts the highest quality resistive element, thereby minimizing colorations introduced by the control. The only real disadvantage is that this is a very costly approach.

The PV10B uses a special precision tracking level control that features a unique multi-finger wiper design to assure reliable contact. This particular control maintains quite good channel-to-channel tracking over most of the range of operation.



Premier preamp volume control vs. IC volume control

A few years ago, in a project to develop a low cost, remote control preamplifier (the Sonographe SC26) we were among the first companies to use an IC chip level control that has recently become increasingly popular. This convenient device offers 20 dB of gain, and precise level control for two channels in one package. The photo shows this chip in comparison to the volume control used in our Premier products.

The cost advantages of the chip should be obvious, especially when one considers that this chip also includes a complete voltage amplifier circuit. With careful attention to power supply design, the audio performance of this chip can be quite good, at least relative to a product priced at under $1000. Recently, however, this chip has turned up as the level control in flagship products ranging in price to over $10,000, including at least two that are marketed as "vacuum-tube" preamplifiers.

I/O Connectors

Even parts as mundane as the input/output connectors are important in designing a preamplifier or power amplifier for optimum performance. The use of gold plated connectors is virtually essential for maintaining a proper connection over time. Machined connectors tend to offer closer tolerances, allowing a tighter, more reliable connection. Finally, we have found that attention must be paid to the metallurgy of the connector. Our Premier products all use a costly gold plated, machined oxygen free copper RCA connector.

Nomenclature

Over the years, conrad-johnson has offered a relatively large number of products, making it a bit of a challenge to keep track of the various models. A brief explanation of our nomenclature will help to identify most of these products. Our bread-and-butter products have had a consistent naming convention that makes it relatively easy to identify a model by its name. The first letter (or two letters in the case of a few products) of the name prefix tells you the function that the product peforms:

P is for preamp ...

P = preamplifier
M = main (power) amplifier
H = head (pre-pre) amplifier
CA = control amplifier
D/A = digital to analogue converter
DR = data reader
D = disc player
E = equalization preamplifier (phono stage)

In all cases except for digital products, the last letter of the name prefix represents the technology employed:

V = valve (vacuum-tube)
F = field effect transistor (fet)

This rule also holds true for the compact disc players (DF1, DF2, DV2b).

The model prefix is followed by a number, indicating the chronological development of the line (eg. the PV12 is the 12th distinct model in the PV line of vacuum-tube preamplifiers) or, in the case of power amplifiers, an indication of the power rating. Finally, some models include one or two suffix letters. This can represent a revision level (eg. PV12A), or, in the case of a

preamplifier, that the model is a line-stage only (PV12AL). In the case of two digital products this suffix is merely a play on words (DA2b and DV2b).

Until very recently, Premier products have simply been ordered in chronological order - the Premier Ten was the tenth distinct Premier model (it happened to be a line-stage preamplifier). Premier models 1, 4, 5, 8, 11, and 12 were power amplifiers, models 2, 3, 7, 10, and 14 were preamplifiers, model 6 was a pre-preamp, model 9 a dac, and model 15 a phono stage. To minimize confusion, it is intended that all future Premier products will include a model suffix which will indicate the function of the product:

LS = line stage
SA = stereo amplifier
CA = control amplifier

Finally, in 1997, celebrating 20 years in the business, conrad-johnson introduced a very special model, the ART (Anniversary Reference Triode) preamplifier. Only 250 of these will be built, and half of these will be reserved for overseas sales.

Questions & Answers

Will Tubes Continue to be Available in the Future?

Military demand for replacement tubes combined with demand for tubes for musical instrument amplifiers (tube circuits continue to be the preferred choice among musicians) should keep tubes in production for many years to come. In fact, a number of new manufacturers are beginning production of vacuum tubes.

How long will tubes last?

On average, tubes should provide top quality audio performance for about 1500 hours, and continue to test good for much longer. Occasionally, gain tubes may go noisy, and output tubes may short. These failures are random, and not predictable. For typical users who operate their stereo system for an average of 10 hours per week, 1500 hours translates to about three years of use if the equipment is turned off when not in use.

Are tubes costly to replace?

Not if purchased from conrad-johnson. Seven and nine pin miniature tubes (voltage gain tubes) are currently priced from $16 to $30 each, EL34 output tubes at $30 each, and 6550 output tubes at $50 each.

Is a technician needed to replace the tubes?

NO. No special equipment or expertise is required to replace tubes in conrad-johnson products. All preamp tubes and small tubes in the amplifiers

are self biased - just remove the old and plug in the new. The amplifier output tubes require a simple bias adjustment using indicators built into the amplifier.

Why is there no on/off switch on the solid-state preamps?

Solid-state preamplifiers require a long warm-up period (a day or more) before they sound their best. Since they use so little power it is practical to leave them turned on at all times. The tube preamps warm up much more quickly, dissipate more heat, and have tubes which wear out, so they are equipped with on/off switches.

Why do conrad-johnson line stages invert phase?

Each gain block inverts phase once. Conventional preamplifiers will use two gain blocks to provide sufficient gain to apply substantial amounts of negative feedback around the circuit. The second gain block inverts phase a second time, returning it to "correct". Our zero-feedback circuits extract enough gain for a line stage from a single gain block. To correct the phase inversion would require the addition of a second gain block, which would degrade the sound quality to no good purpose. Instead, the phase can be inverted again at the speaker connections.

What is wrong with Integrated Circuits?

Class A/B operation, low grade resistive and capacitive elements, and excessive negative feedback (100 to 120 dB). The IC amplifier embodies in one convenient chip everything we are trying to avoid.

Why doesn't conrad-johnson use "balanced" designs?

Balanced connection between components is an important factor in recording studios, and other professional applications where the total length of cabling can easily run into miles of wire. In this kind of application, balanced connection is necessary to prevent this huge "antenna" from picking up hum. This is simply not a factor in home installations.

Doing balanced connection correctly is quite costly, since it requires duplicating the entire signal path circuit (including all controls). This is a tremendous expense to go to for no real benefit. Further, it obviously doubles the circuitry, violating our "simple circuits" principle. Some manufacturers cheat this cost by offering a phony balanced connection (a balanced connector wired to a single ended circuit). While this strikes us as deceitful, it is at least relatively innocuous. Worse are balanced connections achieved by using an IC op amp to sum an incoming balanced signal for single-ended amplification, and then re-split the signal with another IC op amp at the output. This relatively common approach is certain to degrade the sound while adding cost and complexity to the circuit.

Can conrad-johnson amplifiers be "strapped" for mono operation?

The conrad-johnson stereo vacuum-tube amplifiers can have the two channels connected in parallel for a mono amplifier with twice the power of the stereo amp. Contact our customer service representative for instructions. The solid-state amplifiers cannot be connected for mono operation.

Why is harmonic distortion relatively innocuous with tubes and FETs?

Tubes and FETs are similar in that the distortion produced by these devices is almost exclusively 2nd order harmonic distortion. The 2nd order harmonic of any musical note is the same note an octave higher. This musically related tone is part of the overtone structure of the original instrument, so the presence of a small amount of 2nd harmonic distortion merely makes the instrument sound slightly richer in overtones. Odd order distortion, which is prevalent in bipolar transistor circuits, is not musically related to the original tone, and is distracting even in small amounts.

Selling Points

the company:

- company stability - 25 years under Bill Conrad and Lew Johnson
- excellent reputation for customer service
- known for musicality of its products
- products more consistently highly ranked than any other company
- product stability - avoids mod-of-the-week syndrome

the products:

- most musically accurate sound at each price point
- highest quality parts at each price point
- zero-feedback circuits for preamps, low feedback for amps
- elimination of electrolytic capacitors wherever possible
- oversize mains transformers for all power amplifiers
- simple circuits for better sound, better reliability - less is more
- handmade in the USA

the tube products:

- self-bias operation of preamps, and simple, built in bias adjustment for power amplifiers
- relatively few, and common tubes for low replacement cost
- polypropylene capacitors for main power – no electrolytic capacitors in audio circuits or their power supplies
- ample spacing between tubes for cooler operation, longer life

the solid-state products:

- f.e.t. voltage gain circuits for tube-like sound
- polypropylene capacitors for main power supply in preamps
- Over-sized transformers and large computer grade capacitors for stiff power supplies in high-current power amps
- extensive polypropylene and polystyrene "by-passing" of main power supply electrolytics in power amps