VAC PA160 "UNIVERSAL" MONOPHONIC POWER AMPLIFIER

Operating Instructions

Index:

DO NOT OPEN THIS UNIT - THERE ARE NO USER SERVICEABLE PARTS INSIDE. DO NOT REMOVE THE BOTTOM PLATES. LETHAL VOLTAGES ARE PRESENT WITHIN THE CHASSIS. DO NOT EXPOSE THIS UNIT TO MOISTURE OR OPERATE IT IF WET.

VACUUM TUBES BECOME HOT ENOUGH TO CAUSE SERIOUS BURNS. NEVER TOUCH A TUBE WHEN THE UNIT IS ON. IT MAY TAKE SEVERAL MINUTES FOR THE TUBES TO COOL DOWN AFTER THE UNIT IS SWITCHED OFF.

DO NOT PLUG INTO AN AC SOURCE UNTIL ALL CONNECTIONS ARE COMPLETED.

Introduction

The PA160 is a wideband low-feedback monoblock power amplifier producing approximately 160 watts per chassis in standard trim. It is largely based on the critically acclaimed VAC PA90C-1 circuit, which was has been praised by many authorities since its introduction in 1990. This improved version delivers a new level of performance, musicality, flexibility, and convenience.

Premium parts are employed throughout, including 14 pound 22 section bifilar-wound ultra-wideband output transformers, polypropylene and polystyrene signal capacitors, high current rectifiers, low ESR power supply, and proprietary wiring. The quality of parts and careful layout allows the use of very little or no feedback for high sonic purity and low distortion.

Your VAC Power Amplifier is designed not to the latest fad but to substance, providing the highest quality of sound. Time spent familiarizing yourself with this manual will be well rewarded.

"Universal" is descriptive of the PA 160's ability to adapt to virtually any system context. Some of the features of your power amplifiers include:

- configuration switches allow the use of KT88, KT77, KT66, 6550, EL34, or 6L6GC output tubes
- 160 watts power output with the fabulous new Golden Dragon KT88 (standard)
- switch for triode, ultra-linear, or beam power/pentode modes of operation
- user variable negative feedback
- adjustable ground configuration switch to best compliment the associated preamplifier
- multiple impedance taps to match loudspeakers from 1 to 8 ohms from massive 21 section wideband bifilar output transformers
- high current capability
- XLR and RCA input jacks for compatibility with balanced or single-ended sources
- simple front panel bias indicators and adjustments allow easy monitoring and optimum performance (no meter required)
- balanced push-pull circuitry, with push-pull conversion in the first stage to better exploit the inherent advantages of push-pull operation and to allow improved performance of the driver stage
- audio path completely hand wired, allowing components to perform nearer to the theoretical ideal
- non-magnetic chassis
- energy storage is distributed inside the chassis to place it nearer to the point of demand and dedicated to particular uses, ensuring superior isolation of the various stages.

Unpacking

Do not lift the PA160 by the transformer cans!

Each tube socket on the amplifier is covered by a small round sticker. The color of this sticker corresponds to the color of the sticker on a tube. Fit each tube into the matching socket, first *removing* the sticker from the tube and socket. Handle tubes by the *bases*, not the glass. The bias levels for the output tubes have been factory set, but should be checked during the installation procedure.

Installation

Physical requirements:

1) Provide adequate ventilation - allow at least 3 inches above and 1 inch to each side.
2) Do not place in a completely enclosed cabinet.
3) Do not stack other equipment on top of the VAC units.
4) Do not operate on carpet or any other surface that might block air flow.
5) The chassis and power transformers will become hot in normal use.
6) Do not allow the chassis of the VAC components to touch any metal parts, such as the frame of an equipment rack. This might create a parallel ground path that will degrade the sound of your system.

Electrical connections:

1) Complete all installation steps before plugging the amplifier into the AC mains supply.
2) Connect signal inputs to the power amplifiers. Single ended interconnect cables equipped with RCA phono plugs or XLR cables (balanced or unbalanced sources) provide the input to each channel - DO NOT CONNECT TO BOTH INPUTS AT THE SAME TIME.
3) Connect loudspeakers between the appropriate pair of binding posts on the back of the power amplifiers. Most popular speaker cables can be accommodated by the output terminal strips. Output impedance matching is available for loads of 2, 4, and 8 ohms. Connect one lead of the speaker cable to the "G" position, and the other to either 2, 4, or 8. The "G" terminal is at ground potential, and the amplifier does not invert phase.
4) Do not connect two amplifier outputs to each other.
5) Connect the AC cord to the power source indicated by the configuration card under the fuse (100 volts AC, 120 volts AC, 220 volts AC, or 240 volts AC at 50 or 60 Hertz).
6) Follow the BIAS procedure described in this manual to set the idle current. Check the idle current at 1 minute, 30 minutes, 1 hour, and 2 hours. Also, read the section entitled INSTALLING NEW OUTPUT TUBES.
7) Do not operate the amplifier unless connected to a loudspeaker or load resistor.
8) Do not switch on an *unmuted preamplifier* or source component when the amplifier is operating. The turn-on surge from an unmuted preamp could potentially damage the PA160, or cause the PA160 (or most high powered amplifiers) to deliver enough signal to damage the loudspeaker.
9) Check that the tube type switch is set to match the output tubes fitted.

Operation

Continuous operation is not recommended. If the amplifiers will not be auditioned for a few hours it is best to turn them off. This avoids undue stress to the KT88 output tubes, whose lives average between 3,000 and 8,000 hours depending upon brand fitted and random variations within the tubes themselves.

Do not operate the tube type switch while the unit is turned on.

As with all high fidelity products, the sound characteristics of the VAC amplifiers change somewhat as they warm up. Good sound will be achieved within 15 minutes of operation, with subtle changes occurring for up to one hour.

Please note that the initial break-in time of high resolution audio equipment is infuriatingly long. The PA160 will continue to season for at least 200 hours. Typically, the early sound of the amplifier will be less extended, dynamic, and coherent. Then the sound will improve noticeable, followed by a period of darker sound, finally giving way to the desired musicality. Patience, as they say, is a virtue.

Any time that the VAC Power Amplifier has not been used for a few weeks the sound may be different. This is also normal for high resolution audio equipment. Optimum sound should return after a few hours. Also be aware that many components display the need for a new break in period after being transported in unheated cargo aircraft.

Bias Adjustment

Your VAC Power Amplifier has been shipped with output tube bias preset. This should be checked when you install your amplifier, and periodically thereafter. It must also be set whenever an output tube is changed or when the output operating mode is changed.

Adjustment of the output tubes is quite easy, and requires only a small screwdriver. On the front top of the amplifier are four green LEDs, each with an adjacent adjustment control. Adjust the LEDs to be off, just shy of green, when the amplifier is not playing music. To set, turn the control clockwise until the LED *just begins* to glow green, and then back the control off *slightly* until the LED goes out.

As music plays, the LEDs will flicker off and on. Check the bias if you ever see an LED stay green while music is not playing, or if an LED does not illuminate when music is playing.

Any tube that can not be adjusted to the correct bias point should be replaced. Any tube which requires constant readjustment should be replaced immediately. Never operate the amplifier with an LED that shows green when music is not playing.

When installing new tubes, set the bias controls counter-clockwise. Check the bias of both channels as the amplifier warms up - don't wait ten minutes.

Bias levels should be checked monthly to ensure optimum sound quality. It is not unusual for the bias to change with time, particularly when tubes are new. The greatest amount of drift occurs during the first 200 hours of a tube's life. The drift may change direction periodically, such that the bias control must be increased and later decreased, or vice versa. Check bias if the sound seems lacking in detail or dynamics.

Fine Tuning Your System

The VAC PA160 offers unparalleled opportunities for fine tuning your system for best subjective reproduction. At first glance this may seem a bit intimidating, but it's actually quite easy to do. The possible adjustments are output stage operating mode, adjustable negative feedback, output impedance matching, and output tube type.

Before critical tuning, be sure that the amplifier is fully broken in, having operated for at least 150 hours. Play several different recordings that you are familiar with to get used to the sound of the system.

Start with the factory settings. Listen to a bit more feedback, then a bit less. If your speakers' impedance falls between two output taps, try them both. Selecting the combination that best matches your system is not a question of right or wrong in the engineering sense. It is a subjective exercise, much like adding seasonings to food. Experiment at your leisure, and select the settings which make the overall system sound most like music.

Output Stage Operating Mode

The PA160 output stage may be operated in pentode/beam power, partial-triode (ultra-linear) or full triode strapped modes, at your discretion via a single switch. Although we often change the mode with the amplifier in operation, we strongly suggest that you turn the amplifier off before operating the mode switch. When changing the mode, be careful not to burn yourself on the output tubes. Turn the switch to the position indicated, then power the unit up and listen.

The greatest power output is available in the pentode and ultra-linear modes, while power in the triode mode is least. Damping factor is greatest in the triode and ultra-linear modes. Triode operation offers somewhat more distortion at low power levels, somewhat less distortion at moderate power levels, and somewhat less critical load impedance matching. Speaker impedance matching is the most critical in the pentode mode.

Experience reveals that the triode mode will generally have the leanest and tightest sound, with somewhat more image depth. Ultra-linear typically shows more drive and "jump" with a wider soundstage. Pentode is richer still, but might lose air and openness on some speaker systems. In many ways this is an issue of system matching, and universal recommendations do not exist.

To get an idea of the sonic differences, start with the ultra-linear mode with feedback set to "D." Then try pentode with feedback at "D" or "E." Compare this to triode with feedback at "A."

Any level of feedback may be used with any operating mode.

Note that the bias current must be reset for each mode. Follow the bias procedure to restore the idle current to proper value.

Note also that the sensitivity of the amplifier is different in the three modes. Adjust the volume controls on your source component accordingly.

Feedback

The feedback controls are provided for adding controlled amounts of loop negative feedback to the amplifier. The exact amount depends on the tube type fitted and the output operating mode selected. The exact numbers are given in the specifications section.

The "A" setting indicates no loop feedback, while "B" through "F" correspond to increasing amounts of negative feedback.

A given amount of feedback reduces the sensitivity of the amplifier by that amount. For example, if you add 4 dB of feedback, you will need to turn your preamplifier up by 4 dB to achieve the same volume.

As small amounts of feedback are introduced, the sound will tend to tighten up in some ways. At the same time, the frequency response of the amplifier/loudspeaker combination will change. With dynamic speakers, very low amounts of feedback may be satisfactory, while greater amounts may dry and brighten the sound, add grain, or cause bass anomalies to appear. With highly reactive loudspeakers, such as electrostatics, more feedback may produce a more open, airy sound.

There is no "optimal" setting for this control in an engineering sense. While feedback improves static damping and lowers some forms of distortion, it also weights the relative balance of distortion components to a higher order. In other words, there's a little good and a little bad about feedback. Listen, and use the setting that provides the best overall subjective performance of your system.

Ground Configuration Switch

The way in which the components of a system relate their audio grounds to the power line ground can have a significant impact on sound quality and noise level. The PA160 is fitted with a ground adjustment switch, located on the top of the chassis near the output terminals. This should be adjusted for best sound, or, if noise is a problem, for lowest noise.

The generally preferred setting for this switch is labelled "Normal" or "Lifted." This largely isolates the audio and power grounds, thus preventing redundant signal paths between the components of your system. Under certain unusual conditions, such as a preamplifier with a floating audio ground, a buzzing sound may be heard in high gain configurations, such as pentode mode with zero feedback. This buzz can usually be eliminated by setting the ground switches to the "DC" position, or by connecting the audio ground of your preamplifier to a true ground. The latter approach may be preferable, and should be tried if you can conveniently do so.

In very stubborn cases, try setting one PA160 to "Normal" and the other to "DC."

Some audiophiles also experiment with the "DC" ground position and the power cords on "cheater plugs." Whatever the sonic goods or bads of this, it is usually regarded as an unsafe engineering practice and should be avoided.

The VAC CPA1 and CLA1 preamplifiers do have floating audio grounds, so some buzz may be noticeable in very high gain positions. If this is a problem, we recommend leaving the ground switches in the "Normal" position, and attaching a lead from the ground post on the preamplifier power supply to the ground post on the main preamplifier chassis.

Output Impedance Matching

We strongly suggest that you experiment with the three available impedance connections for the best sonic match with your system. Since no loudspeaker represents an unchanging impedance at all frequencies, it is impossible to assert with certainty which output tap is appropriate to use. In many systems an amazing difference in sound will exist between the various impedance taps.

You should consider the output impedance markings on your VAC Power Amplifier as follows:

"8 ohms" matches loads between 4 ohms and 8 ohms
"4 ohms" matches loads between 2 ohms and 4 ohms
"2 ohms" matches loads between 1 ohm and 2 ohms

Most loudspeakers vary outside of any one of these ranges, which is why experimentation is essential. We often find that matching a speaker's minimum impedance is more important than matching its nominal (average) impedance.

If you bi-wire your system (run separate speaker leads from the amplifier to the high and low frequency transducers) you may discover that two different impedance taps work best. For example, with the early Martin Logan Sequel II we found that the bass speaker was best matched with the 4 ohm tap, while the electrostatic panel was best controlled by the 2 ohm tap. To achieve this connection, the black leads of both speaker cables connect to "G", the red lead for the panel connects to "2", and the red lead for the woofer connects to "4". With later Sequels we use the 4 ohm connection for both drivers.

Sonic Troubleshooting

If the sound of your system ever seems strange, or if there seems to be a difference between the channels, *check all of the switch settings and connections*. The two chassis should be set to the same tube type, grounding, operating mode, feedback level, and output impedance.

If the settings are the same, try removing and cleaning the cable contacts - sometimes materials are found on RCA plugs and XLR pins that aren't readily visible, but can dull the sound.

If the symptom persists, move the tubes one at a time between the left and right channels. Any sonic problem that changes channels when the tube is moved is probably the fault of the tube itself, which is readily replaced. Be careful not to burn yourself on hot tubes, and to readjust bias settings when you move output tubes. Do not remove tubes while the amplifier is running, or run the amplifier without tubes.

If a static, rushing, or hissing sound is heard, it may be the fault of a tube. As above, move the tubes one at a time between the left and right channels, starting with the front-most 6SN7 tube. Listening after each move until you hear the noise. When the noise changes channels, the culprit will be the tube just installed in the newly noisy channel, and should be replaced with a new or known good tube. If a tube is not identified, reverse the interconnect cables at the back of the PA160's only (left input cable moved to right power amplifier, etc.). If the noise changes channels, it is originating in the preamplifier or associated source component.

Tubes in General

It is a truth that each brand of tube sounds different in a particular high resolution circuit. This is because no two manufacturers make a tube type in quite the same way, and the central tendencies of the performance parameters will differ slightly with each maker. To emphasize the point, examine the plate structure of any two 12AX7 from different manufacturers will probably find that they may not even the same shape and size. (Be careful here, as often a tube is made by a firm other than indicated on its label. In the heyday of tubes it was common to crossbrand between major labels, such as GE and RCA. Today many labels do not manufacture their tubes at all, including Gold Aero and RAM.)

This sonic variability may at first seem a liability, but further thought will reveal that it is an advantage, just like the ability to adjust VTA on a tone arm. The owner of a tube amplifier can select those tubes which sound like the real thing in his/her specific system. Of course, if the manufacturer you prefer is rare you may want to purchase a few spare tubes for the future.

Different types of tubes will also tend to sound different (ex: 6L6GC vs. EL34 vs. KT88).

How long should tubes last? It has long been known in professional circles (and probably now forgotten) that a tube such as the 12AX7 will display better performance characteristics after two years of continual operation than when it was new. In normal use it is not unusual for a low level tube to last 10 years or longer. Output tubes are another story, as they are continually providing significant amounts of current. Here the sound is your best guide. Certainly tubes should be replaced when the amplifiers can no longer meet specifications or when (if you have access to a tube tester) the tube's emission is significantly down or its transconductance is substantially out of specification. In normal use, output tubes will last at least 2 years and perhaps more than 10 years.

It is normal to see a slight violet glow in a power tube such as a KT88 or EL34. However, a vivid violet indicates excess current flow through the tube and should be investigated.

VAC can test tubes for concerned customers.

Low Level Tubes

The Voltage Amplifier/Phase Splitter and Driver tubes in the PA160 are the 6SN7 medium mu octal twin triode. Your amplifier is fitted with the current production British/Chinese Golden Dragon, which we find superior to the NOS types we have tried. There are dozens of versions of this tube available in new old stock (NOS) from a variety of sources. It would be impossible to characterize them all. The usually are not terribly expensive, and may be worth experimenting with. VAC welcomes your comments.

One NOS variant worth mentioning is the RCA "Special Red" industrial version 5692. These represent the pinnacle of RCA's tube knowledge.

Other equivalent type numbers are 5692, 13D2, B65, ECC32, QA2408, QB65, and CV1988.

Output Tubes

Your VAC Amplifier can use the following output tube types: KT88, 6550/6550A, KT77, EL34/6CA7, KT66, 6L6GC. ***DO NOT MIX TUBE TYPES***. Set the tube type switch to correspond to the tubes fitted and adjust bias level for proper operation.

The standard output tube is the new Golden Dragon KT88, which possess a nice combination of image size, tonal weight, and openness. By contrast, the Golden Dragon EL34 provides a leaner, sharper sound. The Golden Dragon KT66 is darker in tone than a KT88.

The 6550 is not likely to show as long a life in the PA160 as a KT88, and EL34 lives may be somewhat reduced in the pentode operating mode.

The following comments contrast several available brands in the KT88/6550/6550A family:

M-O Valve Company/Genalex/GEC KT88 (U.K.) PRE-1970 (date approximate):

An accurate and sweet tube with good bass quality. Quality is surprisingly variable for a premium tube. World wide supply is limited. *Highly recommended.*

M-O Valve Company/Genalex/GEC KT88 (U.K.) POST-1970 (date approximate):

Hard, glaring sound, only fair detail. Not recommended.

New Golden Dragon KT88 (June 1994 onward):

A new variant of the Chinese KT88 developed in Great Britain. An very good tube, close to the original, great speed, openness, imaging, and balance. The new version (June 1994) is much improved, particularly as regards reliability. It may be recognized by its slightly taller bottle and single top mounted getter. *Highly recommended.*

Generic Chinese KT88 (including ARS, Gold Aero, Ram, Penta, Jolida, etc.):

Actually a fairly good sounding tube. Bass quality somewhat phasey, some mechanical sound due to a subjective dip in the upper-mid-range. Some samples make rather alarming noises on warm up and cool down, often heard through the speakers. Reliability is variable.

National NL-KT88-USA:

A new version on the KT88 produced by the US arm of the Richardson's organization. Visually very similar to the original and sonically satisfying, close to both the original and the Golden Dragon. Slightly lightweight sound, but sweet. Very expensive.

Golden Dragon 6550A:

A good tube with more subterranean bass and mid-range zing than a good KT88. Loses in terms of ease and dimensionality. May help wake up a sleepy system, but overall less natural. Good sound.

US made RCA and Tung-Sol 6550:

Early 6550 type in the "coke glass" bottle. Pretty good sound.

GE 6550A (applies to those manufactured in USA by MPD):

Overall hard and lacking in air. Not recommended.

Phillips/ECG/Sylvania 6550A:
Similar to the GE tube, perhaps a bit better.

Sovtek 6550:
Samples tested do not bias correctly, having insufficient current flow. Not recommended.

With regard to the EL34/6CA7/KT77 family, the following observations apply:

M-O Valve Company/Genalex/GEC KT77 (U.K.): Accurate and dramatic imaging, great nuance, control of dynamics, sweetness, and bass quality. Quality is surprisingly variable for a premium tube, and we have had to reject about 10% of the KT77s we have purchased. Most EL34s are more thinner sounding or less coherent by comparison. World wide supply is limited, although Golden Dragon has announced a forthcoming replica. *Highly recommended.*

Golden Dragon EL34: A new version of the EL34 designed in Great Britain and manufactured in China. A good tube, more open, detailed, and dynamic than the East German EL34. *Recommended.*

Gold Aero KT77: Depending on vintage this *reportedly* can be a relabelled GEC KT77 or an EL34 with the KT77 name rolled onto it. Take care. We recommend staying with tubes that are accurately labelled.

Russian & German Made "KT77": EL34 variants. Not recommend.

Siemans, EUI, and National EL34 (Germany): A generally warm & midrangy tube with fairly good detail. May be somewhat bland in some systems. Reasonably reliable. Has also been seen with the Telefunken brand. *Acceptable.*

GE EL34/6CA7 (applies to those manufactured in USA by MPD): Robust tube with bass similar to better solid state amplifiers. Overall a bit wooly sounding. This is one of the large bulb variants of the EL34, and is actually a beam power tube.

EI EL34 (Yugoslavia): Similar to the East German tube, but inferior in most respects. Has unique exhaust tip on the top. Poor linearity. Not recommended.

Chinese EL34J (available from Penta, Gold Aero, Richardsons, & others): Good detail and very liquid sound, this tube may seem a bit soft and bright in some systems. We have been unable to confirm rumors of unreliability.

Tesla EL34, E34L (Czech) (available from Gold Aero & others): Physically well made. Most samples encountered have a soft, soggy, warm sound, although we have encountered a very few with a forward, opaque sound. Not our favorite, but worth trying for a nostalgic sound.

Installing New Output Tubes

Replacement tubes are available from VAC and other sources. It is not necessary that they be matched pairs, although a slight improvement in measured performance may be achieved in this way. Make certain that each tube fits firmly in its socket. A tube that fits loosely may not make correct contact on all pins and might "run away" (read on). It is best not to mix brands of tubes.

ALL POWER MUST BE OFF. Remove the old tubes after they have cooled down (TUBES BECOME HOT ENOUGH TO CAUSE SERIOUS BURNS WHEN IN OPERATION AND MAY TAKE SEVERAL MINUTES TO COOL DOWN). Handle tubes by their bases, not the glass. Install the new tubes firmly and fully in the sockets, taking care to observe the direction of the locating ridge on the plastic center pin of each tube.

Follow the normal turn on procedure and begin the BIAS procedure. While doing this, keep an eye on the plate (the outermost metal structure) of the output tubes. SWITCH OFF IMMEDIATELY IF THEY BEGIN TO GLOW RED. This indicates that the tube is "running away", being destroyed rapidly by conducting excessive current. (Note: with some KT88s a slight dull orange glow may occur over a very small section of the plate, usually at an edge. This is acceptable and not the same as running away, in which most of the plate will become bright orange or red.)

Tubes may run away for several reasons:

1) The tube is not fully inserted in the socket.
2) The tube fits loosely in the socket and thus can not make correct contact. Such a tube is unusable and should be returned to its seller. (Note: British KT77 normally have pins with slightly smaller diameter, so pay close attention to fit.)
3) The tube is defective.
4) The bias is misadjusted.
5) There is a problem with the amplifier. Contact VAC or your dealer to arrange service.

In the event that trouble is encountered, try another tube. Stop if the problem persists and consult with your dealer or VAC.

Follow the BIAS procedure described previously in this manual to set the idle current at 70 milliamperes per tube, checking the idle current at 1 minute, 30 minutes, 1 hour, and 2 hours.

Replacement of Low Level Tubes

All power must be switched off. Allow tubes to cool down. Remove and replace with new tubes of the appropriate types, noting the location of holes in the socket and pins of the tubes. Handle tubes by the bases, not the glass.

Replacement tubes are available from VAC and other sources.

Care of Chassis

VAC chassis are aluminum for superior electromagnetic performance. The finish is matt and textured powder coat paints. This finish is durable but can be scratched or chipped, just as that of a fine automobile may be damaged. Cleaning with a slightly damp cloth WHILE THE AMP IS SWITCHED OFF AND UNPLUGGED should suffice.

Need Help?

Please call us with any questions you may have. It is better to ask than to guess.

SPECIFICATIONS

The VAC System has been developed with the critical ear as the major arbiter of quality, with both conventional and unique measurements providing insight and guidance as necessary. The lack of emphasis on measurements is due to the fact that engineering's arsenal of equipment and techniques do not operate on the pattern recognition principals that control human perception of sound. In the immortal words of Daniel von Recklinghausen, if it measures good and sounds bad it is bad. If it measures bad and sounds good you've measured the wrong things.

The following describes typical measured performance of a PA160 operated at 120 VAC, 60 Hz.

Power Output: Continuous average power at 1 kHz depends upon the tube type fitted and the operating mode selected. The following table summarizes a few popular combinations. The entries show power, and load impedance connected to the 4-8 ohm tap. In each case THD is less than 2% with feedback setting of "A" for triode, "D" for ultra-linear, "E" for pentode.

Mode	KT88	KT77	EL34	6L6GC
Pentode	160/4	125/4	150/4	100/4
Ultra-Linear	152/4	120/4	118/4	70/8
Triode	79/4	60/4	58/4	30/5.5

Frequency Response: down 0.5 dB at 5 Hz and 48 kHz, ref 0 dB = 1 watt @ 1 kHz.
down 3.0 dB at 3 Hz and 82 kHz, ref 0 dB = 1 watt @ 1 kHz.

Power Bandwidth: down 0.5 dB at 12 Hz and 42 kHz, ref 0 dB = 150 watts @ 1 kHz.
down 3.0 dB at 8.5 Hz and 75 kHz, ref 0 dB = 150 watts @ 1 kHz.
Ultra-linear mode, KT88 tubes.

Distortion: Typically .23% THD at 1 kHz 10 watts, < 1% 20-20,000 Hz.

Noise: < 1 mv at the output, S/N ratio > 88 dB

Negative Feedback: Variable. Table shows amount for triode/ultra-linear/pentode modes.

Set	KT88	KT77	KT66	6550	EL34	6L6GC
"A"	0.0/0.0/0.0	0.0/0.0/0.0	0.0/0.0/0.0	0.0/0.0/0.0	0.0/0.0/0.0	0.0/0.0/0.0
"B"	1.0/1.3/1.9	1.2/1.6/2.5	0.7/1.1/1.4	0.9/1.2/1.8	1.1/1.5/2.0	0.7/1.1/1.4
"C"	2.0/2.6/3.8	2.5/3.4/4.7	1.5/2.2/2.9	1.8/2.5/3.6	1.3/3.0/3.9	1.5/2.2/2.9
"D"	3.0/3.8/5.4	3.5/4.6/6.5	2.3/3.1/4.0	2.5/3.5/5.0	3.2/4.2/5.4	2.3/3.1/4.0
"E"	4.0/5.2/7.1	4.7/6.4/8.5	3.2/4.2/5.5	3.6/4.9/6.8	4.5/5.7/7.1	3.2/4.2/5.5
"F"	5.0/6.5/8.6	6.0/7.6/10	4.4/5.4/6.7	4.5/6.0/8.2	5.6/7.0/8.6	4.1/5.3/6.6

Absolute Polarity: Does not invert signal polarity.

Fuse: Slo-Blow type, 4A for 100 & 120 Volt configuration, 2A for 220 & 240 V.

Power consumption: 288 watts at idle, 528 watts driven to full power.

Dimensions: 11.75" x 8.5" x 20.5"

Weight: Approximately 53 pounds each (unboxed)

Standard tube compliment: 4 x KT88 (new Golden Dragon version), 2 x 6SN7.