

RM-10 MKII

OWNER'S MANUAL

BY

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FOREWORD

I hate reading instruction manuals. Imagine how I feel having to write one. I encourage you to read this manual. It is many things: a bit of philosophy, a bit of humor, and a bit of scientific discovery all centered around the amplifier you now own.

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INTRODUCTION

I wish to acknowledge your wisdom in buying Music Reference products. In this world of ever-increasing consumerism, you have chosen the high road of efficiency, performance, reliability, and ecology. These factors require you to realize more and more that when you are buying any product you are largely buying the knowledge and experience of the people who designed and made the item. The RM-10 represents three years of development and daily listening. Its evolution is so unusual that I have chosen to write the story rather than a boring instruction manual so that you may better know and care for your amplifier.

This amplifier represents another product in the Music Reference line that adheres to the postmodern philosophy so well expressed by William Irwin Thompson in his book, Darkness and Scattered Light:

"If resources are rare, and every metal is a precious metal, then goods will have to become very good indeed. The world of built-in obsolescence and of heating up the economy through advertising will have to give way to an economy in which a power saw is built in a craft-guild workshop to last a hundred years. To produce such an instrument, we will need not an army of industrial proletarians in Detroit but a workshop of contemplatives crafting an instrument with Zen mindfulness."

Indeed, we can no longer waste the Earth's resources on an amplifier or another product that will be in the dump in five to ten years because it is not worth fixing. Music Reference products are designed and built with the thoughtfulness to allow for reliable use for 100 years. Certain parts will have to be replaced in that time, but they will be easily replaceable so the product can be economically serviced by a technician. Given enough information and practice you may become that technician.

About the LOGO on your amplifier:

The logo on the transformer cover of your amplifier is a stylized representation of what goes on in the invisible electron world of one channel. Its function is to enhance the beauty of the amplifier in a meaningful way. To interpret it, only a few rules need to be stated. To some, I hope, even these will be unnecessary. You might wish to study the logo first before reading on.

The arrows show signal phase, not direction, as AC signals do not really have a direction. Thus, an arrow to the right is positive and an arrow to the left is negative, or 180°. Arrow size denotes signal strength. The fan shaped devices are valves (tubes) with triodes having one gate in the center and pentodes having two. The fan shape represents the spreading of electrons as they flow from the cathode at the bottom, to the plate that collects them at the top. The hourglass shapes signify resistor loads where currents are converted to voltages. Note that the first tube inverts and amplifies while the second provides equal and opposite phases with no gain. These two triodes exist within the 12AX7. The output tubes are the larger fans which are connected to the output transformer. The boxes show windings, with more windings on the primary than the secondary. The horizontal box connected to the output tubes is the power supply and the vertical box at the far right is the load.

THE DESIGNER'S TALE

When I select a product, I consider that I am buying the experience and knowledge of the designer who conducted the engineering on the product, along with the skills of the people who crafted it, and the attitudes of the management team that I trust will support it through its life. Since you are buying my knowledge and experience, I feel inclined to tell you about myself and Music Reference.

My first knowledge of the insides of a tube amplifier came in 1956 when at the age of five I watched my father's every move as he built his HeathKit Mono Hi-Fi system. The amplifier was a "Williamson Type" model W4-M, the preamp a WA-P2, and the FM tuner an FM-3A. I still have all three in working condition including the manuals that instructed my father how to build them under my watchful eye. The manuals are dated 1954, just two years after Heath released its first Hi-Fi kit. Heath was the largest and most professional of the companies to offer kits for audio, amateur radio, test equipment, and other interesting electronic products from 1952 - 1991. I built a dozen in my youth, including the dual trace oscilloscope (1965) that we still use in our service department and the IM Distortion Analyzer (1963) used to test your RM-10. The scope, which is all solid state and built on printed circuit boards, has been less than totally reliable and is hard to service. The older IM Analyzer is built on a chassis with tubes and has never failed (Lesson One: Design for reliability!).

My father's Hi-Fi served us well for several years and then developed a noise in the preamp that my father could not fix, nor could Dr. Joe our ham radio friend, nor could I at first. I must have traced that problem on and off for months trying everyone's suggestions: noisy tube, noisy (leaky) capacitor, and finally noisy resistor. Of course, the culprit turned out to be the high-quality precision part which we least suspected. It was here I learned that the most expensive parts are not always the best. I continue to see this when Kavi Alexander of Water Lily Acoustics brings me his tube microphones and preamps that have had their resistors replaced by expensive "audiophile" brands, only to have the noise rise above the level of the removed cheapies. After installing my selected brand of low noise resistors (the same ones I use in the critical locations of your RM-10) the noise faded into oblivion. Many of the current "audiophile" resistors have been chosen based on their high price or exotic materials, often by people that do not understand noise mechanisms. Their makers are often concerned with precision and other characteristics that non-audio applications require. I have not found low noise to be one of them (Lesson Two: Expensive resistors are not always the best!).

Other than the one resistor the Heath preamp was trouble free. I wish I could say the same of the power amp. After eight years of flawless operation a noxious smell came from the cabinet in which the amplifier lived. It was the smell of fluorescent ballasts cooking that we all remember from our classrooms. The power transformer in its smooth military-looking drawn metal can was hot and oozing smelly tar all over the chassis. I was alarmed at the failure of this major part that had the appearance of infinite longevity. However, Heath was there for us and \$13.50 later I had a new one to install. Only a few years ago I learned from a maker of fluorescent ballasts that the tar or pitch used in the transformer industry was one of the most unreliable potting compounds. Batches often contained moisture and contaminants that caused oxidation of the internal wires causing open or overheating shorts leading to that characteristic smell of burning tar. Thankfully the insulation industry has improved several orders of magnitude in intervening years so that your transformers are wound with double coated long-life polymer insulated wire and sealed in modern resins. That original

amplifier still works with the original tubes that still give full rated performance (Lesson Three: Never pot transformers with tar, wax, or any other moisture absorbing material!).

Incidentally the FM tuner was probably the most time consuming to build and never worked well. It drifted as it warmed up, had too many tubes, and no style. When it comes to tuners, we should be thankful for solid state. Properly repairing and aligning tube tuners is beyond the expertise of most anyone and best avoided.

My design career began at 11 when I built my first 3-tube Class A single-ended amplifier. I still have the little thing which is capable of about 2 watts. Its description read much like that of a \$5,000 amplifier that the high-end magazines might cover today (should I send it in for review?).

As I grew, I wanted more style than I could produce in my father's basement shop, so I bought my first stereo amplifier kit in 1964 for \$29.95. Carefully perusing the catalogs, I found the best bet to be a Knight (by Allied Radio) KG-240. It had two line level inputs, passive tone controls, and a Class A output stage capable of 9 watts per channel (does this sound like something you just read about in the latest magazine or some manufacturer's literature?). The truth is the little Knight had too much hum that I fixed right away by adding filter capacitance, and had mediocre sound due to its poor transformers and poorly tuned circuit. However, for \$29.95 what could I expect? It wasn't until many years later that I learned the meaning of, "eating the menu instead of the meal." Modern advertising depends on just this principal. It's the difference between the mouthwatering description of the latest fast-food delicacy and the experience of eating it. We also see it in the recommendations of magazines to buy the flashy chromed amplifiers that have less output and higher distortion than your RM-10. Will the joy of polishing all that chrome make up for the poor sound these amplifiers produce under difficult musical conditions.

Around 1964 my interest and the industry's turned to the new "miracle" transistors. I and the giants of the industry all did our best to design good sounding amplifiers with these new devices and we all failed. I even invested \$79 in a compact EICO Cortina 70 watt (total IHF music power rated) integrated amplifier because I wanted more power and because I wanted to graduate from a ceramic cartridge on my cheap Knight turntable to the magnetic Empire 888 I installed in my father's Garrard RC-80. By now my father's system had melded into mine and I was the HI-FI Meister of Melbourne Drive. I had to convert the Garrard to stereo and went through a lot of cartridge damage before I realized it was too rough on the Empire (or any modern cartridge of the late 1960's). I later made the biggest expenditure of my teen life on a Dual 1019 turntable which is still in active service as a dedicated 78 RPM player for my jazz records.

The EICO had its flaws including hum and severe distortion on the phono when the mono switch was used on a stereo record. Although I don't remember measuring its power output then, I did recently and it's about 20 watts per channel into 8 ohms. My dream of becoming a "Kit Engineer" for Knight or Heath was rapidly being eroded by the quality of their designs. When a 15-year-old must redesign flaws out of a professional product something is wrong, or maybe something right was inspiring me to make better designs. Of course, I also had no idea at that time what a manufacturer must go through to produce a product at an attractive price with good service (I had to become one myself to get that lesson). That was the last amplifier I ever bought. From then on, I built my own continuing to follow the progress of the transistor in the pages of Popular Electronics and Radio Electronics through

the 1960s and 1970s. I experimented with many transistor circuits and invented a few of my own to explore the world of transistors in full-complimentary, Class A, zero feedback circuits.

In 1969 I went to the University of Virginia to get my degree in Electrical Engineering where I was the only student in my E.E. program who had built his own amplifiers. I wasn't expecting to be so lonely! I couldn't even find a Hi-Fi buff on the faculty. So, I spent a lot of time in the music department studying music history and theory, teaching students how to use the ARP Synthesizer, and recording concerts on their Revox A-77. I had to go up on the catwalk in the skylight above the stage to insert and remove the batteries in the Sony condenser mics for each recording. Since the adrenaline rush of potentially falling 50 feet through the skylight onto the Steinway below kept me alert for the session, I quickly began reading about phantom powering those mics. Being low on funds I made up some phantom power boxes with some old matching transformers I found lying around and a couple of batteries. Now I only had to go up into the loft for fun!

As a pianist, I was fascinated by the inoperative Skinner type pipe organ in the hall and wanted to play it. Finding the keyboard 50% inoperative due to broken wires, I took on the task of getting it back in action for my midnight "Phantom of the Opera" sessions where I would play Toccata and Fugue in D Minor for my friends. Amid all this fooling around I got my Engineering degree with High Distinction and headed to the world of industry.

I landed at IBM and quickly saw this "great opportunity" was a dead end. I then opened an audio repair shop in the basement of Atlantis Sound in my hometown of Richmond, Virginia. Here I learned about the reliability (and lack of same) in audio equipment. I also learned to swear at the names of those manufacturers who made it hard to get in and out of things. I charged on a flat rate and didn't have time for poor serviceability. I was averaging a unit an hour, start to finish, including writing the ticket. I saw things like the Sony STR-7065 receiver that failed like clockwork after a few years (totally hour-and-heat dependent) because they used a 1/4 watt resistor at 1/4 watt. Didn't they know, I mused, about derating? Did it slip by some engineer's check? Sadly, almost every unit failed, and it cost many customers \$30 to \$50 (in 1974 dollars) to have those one-cent resistors replaced. Many years later I learned the same hard lesson at Beveridge when a properly derated, high-quality resistor failed repeatedly in the RM-1 power supply. I decided that even though the resistor was also within its voltage rating the manufacturer's rating was too ambitious and the best option was putting two resistors of half the value in series. After that there was not another failure of that part. Luckily, I learned that lesson in 1978 and that's why the plate resistor of V1 in your RM-10 is split in two.

For two full years I repaired an average of ten pieces per day, three days a week, for a total of about 2,000 units, from Audio Research to SAE. One day a pair of Futterman's (early OTL amplifiers) came in which kept me busy for a while. When the store owner learned I could make an A-77 sound better than new he offered a \$50 tune-up special. I must have repaired and aligned 100 Revox A-77s. I still have a few in my museum and find them to be aging poorly. The wonderful tantalum dipped capacitors are opening as the years go by. I figured it would take several hours to replace them all because Revox hid them everywhere. They were easy to get to before the motherboard was set deep in the machine. Getting the motherboard out is another time-consuming issue. There I learned about products that were designed for manufacturing efficiency with little regard for repair efficiency.

Cars are similar, some starters you can replace in 1/2 hour, and some take 3 hours. You know that if you keep the car long enough you will replace the starter and the water pump and the alternator, among other things. We don't throw the car away when the starter quits, but we are tempted to junk the Revox when 30 hard-to-reach capacitors are all failing. I don't use my Revox anymore I just look at it. I still use reel-to-reel every day, an equally old (1971) Sony whose capacitors are still good because they are aluminum electrolytics like the ones in your RM-10. As you see I've spent my career studying the reliability of components. Strangely, if we look at the manufacturer's rating for many components, we find things lasting far longer than some ratings would lead us to believe. The capacitors in the Sony are rated for 1,000 hours but are now 23 years old and given my usage have probably seen 20,000 to 40,000 hours. There are about 60 of them in there and not one has failed.

By 1975 I had my fill of fixing things and wanted to become a teacher. So, I went to Stanford University for a master's degree. After one year of classes and student teaching where I became known as Mr. Parts because I had a desk full of this and that, I saw that teaching in a university was not going to be what I hoped for. I then went back to Virginia where I opened the high-end store Audio Art. There I spent several years in sales and service getting to know the audio customer and their needs.

Although I first met Harold Beveridge at Stanford, I got to know him and his products as his dealer in Virginia. In 1978 Bev hired me as a consultant, later to become his Chief Engineer in Santa Barbara. I went to work for virtually no salary to be the student of this very creative, well-seasoned electrical engineer. In the same tradition I have taken on a few apprentices and always have room for those who burn with the desire to understand and make fine audio equipment.

I did what I could to promote reliability at HBI, but Bev was in denial about reliability, and I left after three years. While there I designed the RM-1 preamp and its RM-2 power supply. In the early versions I got caught by not derating the 6DJ8 tubes enough. Although they were run at 1/2 their rated dissipation, I later found that it took derating to 1/4 to get them to last the years I wanted them too. The later RM-1 preamps were darn reliable in their "low power" version especially when one considers that it had over 1,500 components. I also did a solid-state crossover for Bev which was very reliable except that the pots would break loose from the circuit board if the unit was tossed around in shipping. Although they could easily be resoldered, I learned another lesson about reliability.

By 1981 the time was ripe for me to start my own company, Music Reference. My first product was the RM-4 Vacuum Tube Head Amp. I designed it out of the challenge that a tube head amp for a moving coil cartridge was an "impossibility". I had been using the 6DJ8 for three years and knew that quiet samples could be found. I developed the test equipment to measure the "RAM Factor", at first by hand and later by computer, as we do to this day. If you read the Hi-Fi magazines, you have probably noted reviewers solving noise problems with tubes obtained from RAM Tubes. We could have never made the large number of RM-4 head amps and later RM-5 preamps at their extremely low noise levels without the RAM Computer Tube Tester.

Those first RM-5 preamps were delivered in 1981 and are still in service. From my experience of repairing other brands of tube preamps I would say the RM-5 was the most reliable in the field. Part of that reliability is due to simplicity, part due to construction, and part due to the short-circuit proof power supply. As it turns out many tube preamps fail at the power supply. These often fail at turn on, thus giving false credence to the myth that it is better to leave tubes on. They also fail when an owner

or technician slips with the voltmeter probe and briefly shorts the high voltage. After the smoke clears the technician is faced with repairing the power supply before getting back to the original problem. This exercise is then repeated until the unit is repaired or the technician is carried off to the funny farm. I experienced this very problem fixing a popular preamp from the late 1970s which later went through several revisions, disguising the fact that in the original design the pass transistor in the regulated power supply was overstressed by charging the filter capacitors. That experience and others committed me to short-circuit proof power supplies. You should be aware that to this day there are products being designed and produced with power supplies that are failures waiting to happen. In terms of reliability, I cannot overstate the importance of a reliable power supply. If you have that and a reasonably competent design in the audio stages your troubles will be limited to tubes alone. This isn't to say you are clear of designers who choose inappropriate tubes for the application (ex. 12AT7 and 12AU7 for the input tubes), or who operate tubes too hot or at too high voltages. The chapter on the design of your RM-10 will tell you how your amplifier's tubes were chosen.

By 1984 I had added power tube testing to the RAM Computer Tube Tester. The process is entirely different from testing for low noise preamp tubes. It requires extreme precision to achieve accurate matching. RAM Tubes was the first to offer a two-parameter match of both bias and transconductance. I realized that bias matching alone was worthless unless the matching was done at the precise voltages and currents of the specified amplifier in which the tubes were to be installed. That realization made conventional matching a joke. Even today the concept of matching is one of the most misunderstood and abused value-added services in the tube industry. Yet bias and transconductance matching is the only way to get an output stage to perform optimally.

My interaction with these new power tube customers gave me a great deal of information about tube life in various amplifiers and the attitudes of their makers. One manufacturer of a popular low-cost amplifier was quite satisfied with his 1,000 hour tube life. I had discussed tube life with design engineers at Sylvania, GE, and Gold Lion and found that the design life of 10,000 hours could easily be achieved by reasonable derating. The challenge was to design an amplifier with good sound at reduced tube dissipation and safe voltages. On the bench I saw what every amplifier designer before me has seen – crank up the tube current and the distortion goes down. Sadly, **the tube life goes down faster than the distortion**. This led to the challenge of the RM-9 – to design a cool running amplifier (tubes at 1/2 rated dissipation) with good sound. Seven years later many of our customers are still enjoying their original tubes with full performance. The RM-9 was the first modern amplifier to employ B+ fusing to the plates and eliminate the screen resistors that often fail with shorted tubes. Tube shorts are a fact of life, and the RM-9 has proven that smoking resistors are unnecessary. Proper fusing also saves tubes from damage due to intermittent lint shorts which destroy unfused tubes.

This is my background and experience that you are buying with every Music Reference product.

DESIGN PHILOSOPHY

The RM-10 came into being in early 1990 when I noticed I rarely played music above a few watts on my Vandersteen 2C speakers. Later I acquired a pair of QUAD ESL electrostatic speakers and achieved the same listening levels at even lower power. Although I loved my RM-9 with its 12 glowing tubes I wondered if I could do my low-level listening with something smaller and simpler which consumed less power. I drew out the classic two stage, split load driver, connected it to a push pull output stage, and lashed up a power supply. Little did I know the time and effort that would be expended tuning that simple circuit to make it sound like a little RM-9.

I wanted to incorporate the design philosophy that made the RM-9 the well-respected amplifier that it is today. Most important of those criteria is the performance overload. Since the RM-10 was going to be only one quarter the power of its big brother it had better behave well in clipping. People tend to push small amplifiers harder, and I wanted it to be known as a gutsy little amp. As the split load phase inverter is not known for its grace in overload its character was corrected in choosing output tubes with low drive requirements and stabilizing the bias when grid current is drawn. The coupling capacitors do not charge and block off the output grids as in the Dynaco ST-70. I also chose fixed (yet adjustable) bias over the commonly used cathode bias for better overload stability.

Note that this is the first amplifier to achieve 30 watts from one pair of 6BQ5/EL-84 tubes. The classic circuit (Dynaco ST-35) typically achieves 17.5 watts from the same pair. Current EL-84 amplifiers achieve 30 watts but use two pair per channel. Just more tubes to heat up and replace later. They also consume far more power (220 watts at idle vs. 70 watts at idle for the RM-10) which means more heat and shorter life for all the components. Long term cost of operation and freedom from repairs were handled simultaneously. At the recommended bias current of 30 mA per pair the idling dissipation is 9 watts or 75% of rating. One popular British amplifier employed EL-84 tubes at 15 watts with rather short tube life. I estimate the tube life to be 5,000 to 10,000 hours if the amp is played below clipping at the recommended bias setting. Although higher idling current will reduce distortion it can also be reduced by **light loading**. Basically, light loading reduces the output current demand on the output tubes allowing them to be more linear. It also reduces noise, raises damping factor, and allows for more peak current when needed. The only loss is about 20% of the power rating or 1 dB (this is fully covered in the section "Connecting Speakers").

The RM-10 has some miraculous transformers though not magic. The output transformers have insertion loss as all transformers do. They are a carefully chosen balance of copper and iron that achieve wide bandwidth and low magnetic distortion. Compared to traditional output transformers they have less iron to magnetize and therefore less magnetic distortion. They are the culmination of my last ten years musings on output transformer design. The power transformer is rather large by comparison as I am not concerned about magnetizing a large amount of iron. It uses the same grain-oriented audio output quality M-6 in a winding configuration that provides a tighter supply than any other EL-84 amplifier that I have measured. The higher degree of regulation allows the RM-10 to achieve stable imaging and solid impact with transients. By standard transformer ratings it is capable of 250 watts which translates to 400% over its demand at typical music listening levels. Two output taps are provided. Amplifiers with only one tap are too limited for my use. After a complete examination of the currently available binding posts that would fit the cost criterion of the RM-10 I

decided to have my own made of solid brass. These allow the use of a 3/8" nut driver to tighten them. I have seen too many plastic posts strip out or shear off! I set the posts at 3/4" spacing and offer banana caps for those who use banana plugs. The Tiffany input jack was chosen for its good design, high quality, and cost effectiveness. Those three qualities are the criteria for all parts in the RM-10.

Working our way back to the input, you will find it carefully considered. Although it is DC coupled you can insert a capacitor at the input jack to eliminate subsonic or any other low frequencies that might bother your speakers. If you are planning on using the RM-10 as a midrange or tweeter amplifier you can achieve a simple 6 dB per octave crossover by putting a single capacitor at the input jack. The only thing in the path to the first grid is a simple radio frequency filter to prevent interference. It is set at 100 KHz so that it will cause no audible effects. You may be curious about the reason for the two series plate load resistors on the first stage. While one would be within dissipation rating, I have found that high value metal film resistors must be operated well below their full rated voltage to achieve long life. All the resistors in the RM-10 are thoughtfully derated for long life. The critical ones are the same Resista brand we use in the RM-9. I believe that the superior sound of this brand is due to its low voltage coefficient which puts harmonic distortion down at -120 dB. Coupling capacitors are high quality polyester which were found to sound better than any other type.

Since the total value of the first plate load is over 600K ohms it is virtually a current source. This allows the 12AX7 to operate in its most linear and highest gain mode. A neon lamp is used to conduct the large positive grid voltage and protect the second stage during warm up. This often-overlooked detail makes the 12AX7 much happier and extends its life markedly. Unlike the classic split load converters, the RM-10's runs at lower current to extend life. Drive is more than adequate, yet not so much to overload the output tubes. Note the V1 is a RAM grade AB (section 1 selected for low noise) and V2 is grade BA (section 2 selected for low noise). It is essential to have a grade A section as the first amplifier to achieve the very low noise of which the RM-10 is capable.

Taking a lead from its big brother, the RM-10 power supply uses a voltage doubler to receive best regulation from the transformer. This also conveniently provides a stiff and exact half voltage for the screen grids of the EL-84 without using a complex regulator. Since it is tied to a fraction (1/2) of the main supply voltage (B+) it is always just right. I believe the RM-10 to be the first commercial amplifier to employ this technique.

The EL-84 filaments are connected in series to allow a 12.6 volt winding to provide both filament power and bias voltage, thus eliminating the fragile, low current bias winding and its delicate fusing. Unlike other low-cost amplifiers individual bias pots are provided for each channel along with test pots to check each tube individually. All test points are on top for ease of checking and adjustment. The test points were thoughtfully placed outside the optional tube cage and right up front. Since I firmly believe in matched pair output tubes the individual tubes are not adjustable. I know the pitfalls on that road. Tubes are computer selected and RAM Tubes can match replacements using the data shipped with your amp. Individual test points are provided so you can periodically check that both tubes are up to snuff. Output tubes are fused to save them in case of occasional lint shorts or other overloads. The power transformer primary is also fused for protection.

In the power supply, you may note that the customary equalizing resistors have been eliminated from the two series connected electrolytics feeding the driver stage. The "conventional wisdom" of using

equalizing resistors makes no sense on close examination. As electrolytics have a smooth current leakage mechanism they will simply equalize themselves. In fact, the equalizing resistors often drift with age and often cause more harm than good. To my knowledge you have the first amplifier in history with these resistors intentionally missing. I want you to know about this and other unusual aspects of your amplifier so you can have some fun with your technical friends who may raise questions when they study the schematic included in your manual.

Noise is very low in the RM-10 which makes it especially attractive with sensitive speakers like my original QUAD ESL, the Klipschorn, and the high efficiency speakers I am developing to add to the Music Reference line. Owners of these speakers have often been frustrated when an expensive respected amplifier has too much noise. Note that noise figures given in technical reviews are often in error reporting the amplifier to be as much as 30 dB quieter than it is.

For sensitive speakers 35 watts is more than enough. Owners of such speakers can rest more easily with a small amplifier that is far less likely to damage them. Knowing what I do about the QUAD ESL I was always a little nervous with the RM-9 connected to them. What if a cable came loose or someone played the system too loud? A properly sized amplifier is the best insurance for your speakers.

The styling of your RM-10 resembles the RM-9 yet this design was reached the long way around. Although it is obvious to have it resemble its bigger brother, I was not initially able to achieve the look at the price I desired. In its development period over 4 years the RM-10 went from a bread board to an enclosed broad-fronted chassis, to a narrow deep chassis, to a chassis with a shelf for the tubes, and finally to the form you see now. Although a complete circuit board was developed and prototyped, the final design went to hand wiring for its sonic superiority, ease of service, and long life. I expect that most circuit board tube amplifiers, especially the ones with hot power tubes on the boards, will crumble in 20 years. Rest assured your RM-10 will last much longer.

I want you and your audio friends to know that I did not follow “conventional wisdom” when I found it to be unwise. They may also pull out the tube manuals and argue with some of my choices. Tell them they are free to write me with their concerns. For you, I trust that the sound and the reliability I have achieved in the RM-10 is proof enough.

SPECIFICATIONS

In recent years specifications have become less of an issue as the critics and listeners find less and less of a correlation between them and the sound of the amplifier they describe. I feel that specifications do have merit, but we must know which ones are important, what is lost in the pursuit of improving one for another, and what **are** reasonable levels of importance.

I have spent over four years listening to and tuning the RM-10 design, far longer than I have spent on any other product. I have measured too many of its parameters to list here. We use these complete specifications to test the individual parts such as the tubes and transformers, as well as the entire amplifier to assure consistent production. My measurements help assure me that you will hear the same sound I achieved on the prototype that I have been refining since January 1990.

In my listening I found many correlations between measurements and what I was hearing. The amplifier is flat within **0.1 dB** over the audio range so that it will not affect the tonality of the instruments or complex combinations of them. The amplifier has low **distortion of 0.3%** on average level material when played below clipping. I found that high distortion, even if only second harmonic, causes muddiness in music more complex than a soloist. Even piano chords are rendered poorly by high distortion amplifiers. Unlike some transistor amplifiers in which distortion rises in both percentage and order at low levels, the RM-10's distortion falls as level decreases.

Keeping noise at a minimum was given great care in the design as I trust many of you with sensitive speakers will be attracted to this amplifier. The problem of finding a low powered, good sounding, amplifier for these speakers has existed for years. Unfortunately, many high-powered amplifiers have too much noise output (1 to 5 mV) for sensitive speakers (and sensitive ears). The RM-10 achieves an **unweighted noise level of 0.3 mV maximum** which is about 20 dB lower than most amplifiers. The power transformer is also designed for very low physical hum.

The idling **power consumption is a low 70 watts** and rises only slightly when played at full volume. This is a very economical amplifier to operate and has an excellent "Eco-efficiency" rating. This new rating is based on my concern for the planet and our disregard for the energy required to play a little music. It is simply figured by dividing the full undistorted power output of the amplifier by the power consumed at average listening levels. The RM-10 comes in at $70W/70W = 1$. Highly praised "Pure Class A" amplifiers typically have ratings as low as $135W/480W = 0.28$.

The amplifier is immune from line voltage variations and needs no power conditioners or line filters. It works well from 100 VAC to 130 VAC and is designed and specified at 120 VAC. The output regulation is a very low 0.8 dB when used in the light loaded mode with 14 dB of feedback. This makes the damping factor 12.5 (see the section on "Gain Setting" for more information). Output taps are provided for both **low impedance** (4 - 8 ohms) and **high impedance** (8 - 16 ohms) speakers. This is an important concern often overlooked in low-cost amplifiers. Modification kits are available for user installation of standard headphone jacks and direct drive jacks for electrostatic headphones.

Last, by purpose, we come to the specification that is typically first, the power output. I designed the RM-10 to meet my needs for driving the QUAD ESL and other efficient speakers I am developing. I have monitored my power needs with a peak reading power meter over many years and found that I rarely exceed 2 watts peak! Given that, the amplifier has far more headroom than it needs, yet making it any smaller would have no sonic benefit. Note that it does produce almost twice the power of the typical 6BQ5/EL-84 circuits by Dynaco, Fisher, Scott, and others. I quote the architect Frank Lloyd Wright, who often said to his clients, "I can build you a \$5,000 house for \$5,000, but I cannot build you a \$15,000 house for \$5,000." Thus, I have built you a 35 watt per channel amplifier that performs better than any other 35 watt amplifier I have listened to or tested. It is not a 50 or 60 or 75 watt amplifier, but it may please you more than one.

To make your introduction into the world of vacuum tube amplifiers gentler the amplifier has been designed with the greatest reliability in mind. Operating conditions for all the parts have been selected for long life, including the tubes which are biased at 75% of their rating to achieve 5,000+ hours of service. The input tubes should last 10,000 hours.

As a further feature the RM-10 has a toggle switch located on the rear panel that allows you to convert it to a single driver **70 watt monobloc** (see the section on “Monobloc Operation” for further details).

As supplied, the input is direct coupled (DC), radio frequency filtered at 100 KHz, with an **input impedance of 100K ohms. Input sensitivity is 0.86 volts** for full output making it suitable for direct connection to a high-level source with a built in or external “passive” level control. Both sensitivity and input impedance can be easily altered. In addition, an input capacitor may be easily added to convert the amplifier into a midrange or tweeter amplifier with built in crossover (see the section on “Gain Setting” for more details).

Size is a compact 12 3/4” across the front by 9 3/4” deep by 5 1/4” high with no rear protrusions.

Weight is 14 lbs. net and 16 lbs. in the shipping carton.

The designer is: Roger A. Modjeski

INPUT CONNECTIONS

The input impedance of the RM-10 is 100K ohms shunted by 10K ohms in series with a 150 pF capacitor. The impedance is high enough to barely load even the highest output impedance preamp. You can drive several RM-10 amplifiers simultaneously from any preamp.

As supplied the input sensitivity is 0.86 volts for full output. I have found this most suitable with “passive” preamps (preamps that don’t amplify). If your only source is a CD player or a tape deck you can connect it directly provided it has a volume control. Music Reference will soon have a selection of passive control units to allow for the elimination of the preamp.

If you are using a preamp with a gain stage, you might want to employ lower gain to allow more useful range of the volume control and to reduce speaker noise. As many preamps have more noise (when amplified by the RM-10’s high gain) than the RM-10 itself, it is often wise to lower the gain of the power amp to a sensitivity of 1.5 or 2.2 volts. If you know the preamps output noise (typically 20 μ V for a good one) simply multiply it by the RM-10’s gain to get its contribution to noise at the speaker. At the supplied gain of 18, a 20 μ V preamp will send 360 μ V of noise to the speaker and will dominate the total noise given that the RM-10’s noise is 150 μ V on its own. If you own an RM-5 you can simply lower its gain and noise with the internal switches. Keep in mind that we are discussing noise levels far below levels common in the industry.

ELIMINATING NOISE

Since Music Reference equipment is known for its unusually low noise, I want you to know how to find the problems in your system that contribute to noise. The majority of calls I get about noise in systems are the result of improper grounding or using unshielded or poorly shielded “Audiophile Cables”. Music Reference offers a range of cables that provide both audiophile quality sound and professional fit and feel with good shielding, low capacitance, and flexibility.

If you suspect the amplifier is at fault, turn it off, disconnect all inputs and any grounds other than the power cord ground, and **INSTALL SHORTING PLUGS**. It is not valid to mute the preamp as the cables are still attached along with a possible ground loop through the power cords. Shorting plugs are the **only** way to create a “Zero Signal” at the input of the amplifier. They are available from Music Reference or from your dealer. You can make your own by cutting an old interconnect one inch from the plug, stripping the wires, and twisting them together. If you have a soldering iron, the traditional way is to solder a wire from the center pin to the shell of an RCA plug.

Now that you have a “Zero Signal” (remember, an open input is not valid) you can listen to the noise at the speaker with the RM-10 on. Both hum and hiss should be inaudible with speakers that are average sensitivity. If you have a very sensitive speaker (ex. 104 dB/1 watt) you may want to lower the gain to reduce the noise further. Once you have convinced yourself that the amplifier is quiet you can add the preamp back into the system by itself with no inputs connected. If the hum reappears, try floating (lifting) the ground on the preamp using a 3 to 2 prong adapter (“cheater plug”). My favorite ground adapter is a pair of hefty pliers that allow me to remove these offensive grounds permanently. Music Reference preamps have no grounds in the power cords as this invariably causes ground loops with the power amp. Since the interconnect carries the ground just fine there is no need for further grounding on any other components and these “extra” grounds induce loops that are often the cause of hum. Visualize the fact that a ground loop encloses space that has a 60 Hz flux. The loop may have large currents that induce a voltage on the signal return of any cable, even the three-wire ones with the shield terminated on one end only. This bit of voodoo fails as they invariably connect the two units together through the black inner wire. Since the copper shield does not stop magnetic reduction, hum currents then appear in the black. Generally, these cables have lower hum if the shield is soldered on both ends because the total resistance in the ground leg is thereby reduced. So, remember: No loop, no induced hum. Unshielded cables are generally not recommended.

If the preamp continues to cause hum with its ground lifted, suspect the cables or the preamp itself. Substitute the shortest cables that you have. If the hum persists have a qualified technician measure the hum output and compare it to the manufacturer’s specification. Hum needs to be below 20 μ V to meet my definition of quiet.

If the preamp and its cables have passed start connecting signal sources one by one and listening as each is connected. If the hum occurs with volume at minimum, it is often ground loop related. If hum rises with volume setting, it is often source or cable related. The most common cause of source hum is the outside cable connection to your FM tuner. I have received shocks when removing the cables from FM tuners as cable networks and outside antennas often receive generous voltages from surrounding power lines. The simple fix is a “cable isolator” which breaks the ground and passes the signal. These are available for a few bucks. You can make one in a pinch by connecting two 75 ohm-to-300 ohm converters back-to-back. If your tuner has a 300 ohm input just use one to convert the 75 ohm cable to 300 ohm and go right in.

If you have RF problems or clicks from the fridge going on note that they can enter almost anywhere. Again, isolate the components with shorting plugs starting with the RM-10 as it is closest to the speaker. Add the preamp, then the individual sources. If the problem is occasional patience will be required. I have never been disappointed as my efforts have yielded a silent background which I find essential for enjoyable listening.

INTERCONNECTS

There is much loose talk about the “science” of interconnects. This science concerns the topics of resistance, inductance, capacitance, dielectrics, and voodoo. I read most of the literature with great amusement hoping the average audiophile can wade through the voodoo. Here are a few of the more outlandish claims. One noted manufacturer works very hard to make the inductive and capacitive elements of his cable more “ideal” because, “pure capacitors and inductors only temporarily store energy, then ‘squirt’ it back into the network as power.” To make his inductive and capacitive elements purer he increases their values enormously until they rise above the resistance. I would rather have minimum inductance and capacitance, so my cables didn’t “squirt” energy into the signal carried on the cable. The results of stored energy are ringing, hangover, and smearing of the signal. Other makers promote low loss dielectrics so their cables will dissipate less energy. Many of these cables have high capacitance so they end up dissipating more energy than a lower capacitance cable with a less exotic dielectric. I won’t insult your intelligence with any pseudo-scientific voodoo.

After looking at all the losses in speaker cables and the fact that the amplifier, or even better MONOBLOCS, can be enjoyed visually at the speakers, I choose to place them there. A 30 ft. run of high quality, finely stranded, parallel cable has a very measurable loss of 1.4% below 1 KHz where resistance dominates. The loss rises to 6.4% or 0.64 dB at 16 KHz and is doubling per octave.

At Music Reference we make interconnects with the lowest capacitance, lowest inductance, and lowest resistance. Our low capacitance interconnects are in the range of 15 - 30 pF/ft. Compared to some that are ten times higher **ours are much easier for your preamp to drive**. If you are running 30 ft. interconnects so you can have your power amp at the speaker a 150 pf/ft. cable will present a 4,500 pf load to your preamp. At 20 KHz that is 1,770 ohms across the lines, not an easy load for any preamp to drive. Our cable is 1/10 that value and thus 17,770 ohms which is far easier to drive. Connected to an RM-5 set at 18 dB of gain where the output impedance is 1,000 ohms this causes the system to be 0.45 dB down with less cable on your floor. We even have a low capacitance cable of less than 1/8” diameter that can go under your carpet. Heavy speaker cables can’t do that! Our cable has high percentage and low resistance shielding which effectively makes the preamp and power amp chassis one, therefore minimizing hum. We use gold plated Tiffany connectors on all our interconnects.

Our speaker cables are also low capacitance, low inductance, and low resistance. My research has shown that nothing beats a cable where hot and cold wires travel parallel and close to each other in a straight line with no twisting, weaving, or wrapping. This results in the lowest magnitude and least frequency-dependent transmission loss. Long speaker cables are the only choice if you are running a passive preamp. These unbuffered control units generally have high output impedance (10 to 50K ohms) and can drive only short low capacitance cables of 45 pF maximum.

CONNECTING SPEAKERS

Tube amplifiers generally have impedance taps to allow proper matching of the load to tubes. Since tubes operate at high voltages and low currents and speakers operate at low voltages and high currents, there is a need to “transform” the voltages and currents to suit. Once a transformer is employed it is natural to employ a few choices of transformer ratios to best suit various loads.

An output transformer less (OTL) amplifier simply ignores this fact and brute forces the tubes into the load. Therefore, an OTL does not have constant power at various loads. Although I designed the Counterpoint OTL I do not find these amplifiers suitable for cost effective installations. Transistor amplifiers generally avoid output transformers and couple directly to the speaker. Although there are great savings in cost and weight the speakers are often in danger of DC currents when the amplifier fails. Only McIntosh uses transformers on their transistor amplifiers providing both ideal matching and protection. Others have schemes with various degrees of effectiveness. I sleep better at night knowing my amplifiers will not send damaging DC currents to your speakers.

Two impedance taps are provided on the RM-10. The one marked "8" gives maximum power into an 8 ohm load and allows me to honestly rate the amplifier at 30 watts/channel. However, if you are willing to have fewer watts (27 W/channel vs. 33 W/channel, one channel driven), you can enjoy a 78% reduction in distortion and a reserve current of 80%. I call this "light loading" as it requires less than the maximum safe current the tube can provide. In addition, the damping factor doubles, noise decreases, and tube life increases.

To use light loading connect the speaker on the tap that is 1/2 its rating. Thus my 16 ohm QUAD ESL goes from "8" to "0". An 8 ohm speaker would go from "4" to "0". We can provide a "2" tap for light loading 4 ohm speakers upon request, or a 4 ohm speaker can be directly connected to the "4" with good results. Since 4 ohm speakers tend to be less efficient, we recommend using two RM-10 amplifiers as monoblocs with them.

When used as MONOBLOCKS the "8" tap becomes the proper tap for light loading an 8 ohm speaker. This is a very good way to achieve lowest distortion, best damping, and best imaging. As a MONOBLOC the RM-10 is more than twice the amplifier in terms of sonic excellence. Power at clipping will be 50 watts into an 8 ohm load on the "8" tap and the same with a 4 ohm load on the "4" tap. For standard loading and maximum power of 56 watts a 4 ohm load would be connected from "8" to "0" and a 2 ohm load would be connected from "4" to "0".

As the "0" terminals are connected to ground, and the channels are in phase, loads are never connected between the "8" and "4" taps. Speakers always have their negatives to "0" and hots to "8" or "4". In mono position the Stereo/Mono switch connects the "8" taps together along with an internal "driver mono" so that no external straps are needed. The output can be taken from either L or R and the input must be applied to the L input jack only.

The RM-10 is very tolerant of short circuits and will not be damaged by them. I do not recommend driving the amplifier at full power into a short for long periods as it may overheat the tubes or blow the cathode fuse. I do not recommend running the amplifier at full output without a load as this causes exceedingly high (2,000 V) plate swings that can cause the tubes to flash and possibly damage the output transformer. On the other hand, at moderate signal levels I have had no faults as I casually disconnect and connect my speakers.

ADJUSTMENTS, FUSES, TUBE CONSIDERATIONS AND LIFE

SETTING OUTPUT TUBE BIAS

There are two adjustment potentiometers (one per channel) on your RM-10 for setting the bias voltage on the output tubes. As the tubes are matched this is all that is necessary. The driver is self-biased and will tolerate a great deal of tube variation.

To adjust the bias of your output tubes, connect a voltmeter between the test jacks in front of the tubes. From the front the left jack is negative, and the right jack is positive. Connect the meter using mini banana plugs (available from Music Reference). If you are using a digital meter, it will simply show a minus sign if reversed. I prefer an analog meter with a 0.5 volt range. Whether the meter is digital or analog it must be reading at least two digits or 1/3 scale. It is inappropriate to measure 300 mV on a 10 volt scale whether the meter is digital or analog. You are measuring across a 10 ohm resistor so the current is 30 mA for a 300 mV reading.

The amplifier should be pre-heated 20 minutes before checking the bias. If you are installing tubes of unknown bias start with the adjustment fully counterclockwise and raise it to about 250 mV. As the tubes warm up, keep the reading below 250 mV. You can damage new tubes by letting them run too high while you are waiting for the 20 minutes to pass. Using the potentiometer behind the tubes adjust for 300 mv (0.3 V) within 30 mV. This will make the tube dissipation 10 watts each. A setting of 400 mV is the absolute maximum resulting in a dissipation of 13 watts per tube. As the voltages at the test jacks are low you can do this with the amplifier on being careful of the hot tubes. For the cautious turn the amplifier off to change connections and wait one minute for the tubes to restabilize. Adjust the other channel in the same manner.

CHECKING BIAS

I am both lazy and confident about checking the bias on my three year old RM-10. I check it only twice a year because I trust it to be stable. On the other hand, I know some people who can't leave their bias adjustments alone. For those of you who want to check bias often I have made it very easy. I put the test jacks up front so you can do this without removing the tube cage. You can do it as often as you like. I do not recommend leaving the meter connected permanently as there is a small risk of damaging an analog meter if a tube shorts or flashes. If you wish to constantly monitor bias, I suggest a digital meter as most have excellent protection.

The output tubes are rated to last 10,000 hours when run below their rated dissipation of 12 watts. Our experience shows that the tube life is 5,000 - 10,000 hours at this setting. At 13 watts the tube life will be reduced to 2,000 - 5,000 hours. Over 13 watts all bets are off.

Although some amplifier makers recommend bias current high enough to show color in the plates this is a sign of pushing tubes beyond their safe rating. At Music Reference we do not recommend such practices. If you notice a deep red color in the plate (the outermost black cylinder) **turn the amplifier off immediately** and connect your bias meter. The color will always return to black at the proper bias setting of 300 mV (30 mA). The heaters and cathode sleeves surrounding them glow a

bright orange and there is a soft blue glow in the space between the cathode and the plate. This is perfectly normal and part of the visual pleasure of tube amplifiers.

FUSES

The fuses for your RM-10 have been carefully specified. The output tube fuses are 5 x 20 mm, 160 mA **slow blow high interrupting** (ex. Wickman No. 1981-030). The main fuse is 5 x 20 mm standard slow blow: 2.0 amp for 120 V (ex. Wickman No. 19195-057) or 1.0 amp for 240 V (ex. Wickman No. 19195-048). For your protection and safety always replace with identical or comparable fuses. **DO NOT SUBSTITUTE!** Using a different fuse will void your warranty. Since they are difficult to find we have included several extra output tube fuses with your RM-10. You may order additional fuses from Music Reference or your dealer.

TUBES

The six tubes in your RM-10 have been carefully selected by RAM Tubes for the best performance. The operating parameters have also been selected to achieve long life and reliable operation. We suggest RAM Tubes replacements when that time comes.

You may notice a bright flash on the bases of V1 and V2 upon turn on. This is perfectly normal and does not shorten the life of the tube in any way. The flash is due to the filament coating that insulates them from the cathode sleeve. In the process of connecting the tungsten wire to their pins the coating has been removed. This uncoated portion has less thermal mass and thus heats quickly causing the flash. The input tubes are rated for 10,000 hours and 10,000 turn-on cycles. Therefore, it is perfectly okay to turn the amplifier on and off again if you are not listening for an hour or more. Although there is a common myth that tubes do not like to be cycled, I have found it to be without foundation. Filament failures in well-made tubes are so rare I can't remember when I last saw one.

You may notice some hum from your speakers if your hand or an AC cord is placed near V1 or V2. This is normal as the tube is unshielded. If you notice crackling noises, try cleaning the pins of V1 and V2 with a small brass wire brush and **lightly** coat the pins with a cleaner or conductive oil. Cramolin, Kontak, and Track (for model trains) are very conductive and will create leakage paths if carelessly sprayed into sockets. **Use them very sparingly and only on the pins.**

TUBE	TYPE	GRADE	TUBE DATA
V1	12AX7	AB	
V2	12AX7	BA	
V3 & V5	6BQ5 / EL-84	Matched	Group:
V4 & V6	6BQ5 / EL-84	Matched	Group:

MONOBLOC OPERATION

Your RM-10 has a toggle switch located on the rear of the top panel that allows you to select between stereo and mono operation quickly and easily. This is a true MONO switch that when in the mono position connects the driver into an internal mono mode. This is preferable to the common practice

of “Y” connecting the inputs and outputs which requires exact matching of the left and right drivers. Our “Driver Mono” is a new concept in mono/stereo conversion and requires no additional cables or adapters. The switch allows the amplifier to be operated in the standard stereo mode or as a MONOBLOC producing 50 watts with an 8 ohm load on the 8 ohm tap, or 70 watts with a 4 ohm load on the 8 ohm tap. For mono operation the switch must be pointed away from the input jacks and only the left input jack should be used. In mono you can connect your speakers to either the left or right output binding posts or use both to facilitate biwiring. See the section on “Connecting Speakers” for more details on power, reserve current, and distortion.

GAIN ADJUSTMENTS

Amplifier gain affects everything. It is controlled by the value of the feedback resistors R108 for the left channel and R208 for the right channel. The following table gives the values for various parameters of performance as the feedback is changed.

STANDARD LIGHT LOADED

R108/208 (ohms)	C103/203 (pf, 100V)	Feedback (dB)	Sensitivity (volts)	Gain (Vout/Vin)	Gain (dB)	REG (dB)	THD (%)	REG (dB)	THD (%)
680	3,300	22	2.2	7.0	17	.50	.12	.30	.03
820	2,700	21	1.9	8.2	18	.60	.15	.40	.03
1,000	2,200	19	1.5	10	20	.70	.18	.50	.04
1,500	1,500	16	1.1	14	23	1.0	.24	.60	.05
2,200	1,000	14	.86	18	25	1.3	.32	.80	.06
3,300	680	11	.63	25	28	1.6	.45	1.0	.08
4,700	470	9.0	.51	30	30	2.1	.54	1.2	.11
6,800	330	8.0	.42	37	31	2.6	.65	1.4	.14
10,000	220	6.0	.36	43	33	3.2	.85	1.8	.17
15,000	150	4.0	.28	55	35	4.2	1.0	2.2	.21
100,000	22	1.0	.19	81	38	7.0	1.5	4.0	.31
open		0	.17	91	39	8.0	1.6	4.5	.36

Notes: R108 and R208 are values of the feedback resistors in ohms. Feedback factor is given in dB. Sensitivity is the input required at 1 KHz to achieve 30 watts at the 8 ohm or 4 ohm tap. At the 8 ohm tap this equals 15.5 VAC and at the 4 ohm tap this equals 10.9 VAC. Gain is given first as the factor Vout/Vin and then in dB. Gain values are determined by the accuracy of R108 and R208. At the higher gains the intrinsic gains of V1 and V2 become dominant as there is little feedback. The RM-10 is stable over the entire range of gains given in the table. Other gains can be obtained by interpolation.

“STANDARD” refers to connecting a load equal to the marked tap. “LIGHT LOADED” refers to a load of twice the impedance (ex. 16 ohm load on the 8 ohm tap). See the section on “Connecting Speakers” for full details on the advantages of “light loading”. REG is output regulation expressed in dB. It is measured by observing the decrease in output voltage when the specified load is connected to the output. Audio Research started this practice, and I followed it as it is more meaningful to the situation. To get a feel for its relation to damping factor (DF) a REG of 0.3 dB = DF of 30, 1 dB = 10, and 3 dB = 3.

THD is total harmonic distortion at 1 KHz, 10 watts. This level represents the average musical power when the peaks are starting to clip.

SERVICING

TIPS FOR QUALIFIED TECHNICIANS ONLY

WARNING! THERE ARE NO USER SERVICEABLE PARTS INSIDE THIS AMPLIFIER! LETHAL VOLTAGES ARE PRESENT WHILE OPERATING AND FOR SEVERAL HOURS THEREAFTER! REFER TO A QUALIFIED TECHNICIAN FOR SERVICE!

If the main fuse is blown and continues to blow check for shorted diodes D301 and D302. Check for shorted main filters C301 and C302.

If any of the power resistors are overheating check for shorted capacitors or shorts downstream.

The neon lamp will light upon turn on and remain lit until the 12AX7 warms up and starts conducting (about 11 seconds).

If either output tube shows color in the plate (a deep red glow) check the bias for 300 mv across the test jacks. If the color persists the output tubes are probably out of balance, and one is drawing more than its 50% share of the total current. This can be easily checked by measuring the voltage drop across the plate winding resistance. With the meter positive on the red wire at the most positive main filter capacitor (**caution 700 volts!**) measure with the negative first to the blue and then to the brown on pin 7 of each output tube. We purposely leave the top of this socket pin with an open hole so a mini-grabber hook can be attached. These hooks are strongly recommended as they prevent slipping and shorting the 700 V plate to something else. The readings should be equal and about 6.5 volts. If they differ by more than 20% install a new pair of tubes. If the amplifier has a matched quartet of outputs as originally supplied the odd one can be found by setting the bias voltage (as read on the wiper of the bias pot to ground) to the value of the good channel. Then the good tube will read the same as the others and the odd tube will read either higher or lower. A single new tube can be ordered from RAM Tubes by the bias group number supplied with the unit.

Power consumption at idle is 70 watts with the idle current adjusted to 30 mA on each channel.