The Vacuum Tube Logic Book

VTL

David Manley

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Second Edition

Paul Mazzarelli, ed.

David Manley

DEDICATION

This little book is dedicated to all those who love to hear live music, but who also choose to strive to re-create an illusionary resemblance to it in their homes. These people will have the wisdom to understand the difference between the original and the illusion. The wisest of these discerning audiophiles will listen to their music through vacuum tube amplifiers, and they shall stand apart among the rowdy rabble.

— David Manley, California, 1989.

vtlmaster.inx

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FOREWORD

This book is mainly about using the well-proven vacuum tube in today's High End audiophile systems. Unashamedly, we declare our preference for the tube over its solid-state counterpart. With genuine pride (though others may deem it to be downright immodesty) we sincerely believe that **VTL** builds the best vacuum tube equipment on the market today. This book clearly spells out these feelings, though we have tried to counterbalance our pride (or immodesty) with other meaningful information on tube technology; most of this is very hard to come by in modern bookstores. However, lest anyone presume or assume that the main reason for publishing this book is to promote and sell more tube equipment, may we please disabuse them straightaway of that premise. For it is a stated policy of ours that we do not try to make 'converts'; neither at the level of the layman nor the dealer. We love supplying people who know that they want tube equipment and why; we do not like supplying those who are uncertain, or who may have been subjected to sales-pressure. Few seem to know about tubes today, and we feel that that is a pity; for history teaches more than is obviously apparent.

We have endeavoured to keep the book clear and understandable to those who do not have a technical background, without boring those who do. Only time will tell us whether we succeeded.

QUOTATIONS

Reverent and Irreverent

"All amplifiers sound the same." — PETER WALKER

"Amplifiers *do* sound different." — MARTIN COLLOMS

"My amplifier sounds like straight wire." — DAVID HAFLER

"But not like MY wire." — GEORGE CARDAS

"I can make my amplifier sound like your (any) amplifier." — ROBERT CARVER

"Maybe — but definitely not like *my* amplifier." — DAVID MANLEY

"My Dad is a better designer than your Dad." — LUKE MANLEY

"'Views' which cannot be disproved are often perpetuated by the industry and Press as facts." — EDWARD JORDAN

"I find the concept of peak current useful in the case of transistor amplifiers." — MARTIN COLLOMS

"Wipe it!!! It sounds boxy." — ERNEST FLEISCHMANN

"God is in the details." — MIES vd ROHE

"If you can hear it, I can measure it." — ANON. SCIENTIST

"The audio industry as a whole must learn to rely more on the evidence of experienced ears and less on expensive lab equipment." — MARTIN COLLOMS

"Who stole the bass?" — ANTHONY CORDESMAN

"No one stole the bass." — MARTIN COLLOMS

"It wasn't there to *be* stolen." — DAVID MANLEY

"Kindly desist from pouring molten lead down my back." — ANON. PLUMBER

"The dream of every musician who loves his art is to involve listeners everywhere." — AARON COPLAND

"Sound must come first and specification second." — MARTIN COLLOMS

"The virtues of vacuum tubes have a lot to do with music." — WILLIAM CONRAD

"It is sad to say that the hi-fi industry has become a cult in itself, and very few of its devotees have even taken the trouble to listen to live, non-electric, non-amplified music." — EDWARD JORDAN

"I think everybody now agrees that solid-state gear was execrable when it first appeared [but] recently it has begun to sound almost as good as tube equipment, but at far higher cost." — JAMES BOYK

"Successful amplifier designers talk more of an intuitive feel for the subject rather than a reliance on a cast-iron set of rules." — MARTIN COLLOMS

"85% of our annual output of over four million tubes is sold. . .for military equipment like rocket guidance and mobile communications." — GENE COLTRIN: Plant Supervisor, Philips-ECG

"Four-layer Reusen-Shielding (in cables carrying less than 500 mV) is required to isolate electrical interference into the one mega-cycle range; frequency response should easily extend to half that." — Standard Studio Cable Requirements: EMT Wilhelm Franz GMBH, circa 1956

"But are there some important parameters which are not being measured?" — RUSSELL O. HAMM

"My immitative [solid-state] circuits sound very sweet and warm, with many of the virtues of tube circuits, though they still don't have the extreme dynamic range of tubes. I'm amazed by how we continue to hear sonic effects that can't be scientifically measured in the circuits." — KEITH JOHNSON

"With few exceptions, the power supplies inside professional amplifiers look like one big afterthought." — BEN DUNCAN

"No statistical difference could be found." — AES Spokesman

"That which does not appear to exist is to be regarded as if it did not exist." — Jurisprudence art. 3530

"The subject of amplifier damping and its effect on the performance of a loudspeaker is a controversial one, like pentodes versus triodes. . . There is now doubt that many loudspeakers sound better as the damping-factor is increased, because of peaks in the reproduction, which in some instances rise from 10 to 12 dB because of impedance variation. . ." Howard M. Tremaine, D.Sc.

"Tracing distortion is the non-linear distortion introduced in the reproduction of mechanical recording because the curve traced by the motion of the reproducing stylus is not an exact replica of the modulated groove. . . (etched by the cutter-head)." Oliver Read, D.Sc.

1

A Little Night History

THIS IS THE MOST DIFFICULT CHAPTER TO WRITE: THOUGH CERTAINLY NOT THE PURpose of this book, there is quite a lot of 'transistor-bashing' elsewhere in these pages. It's been thirty years and more down the road and, sadly to say, solid-state has still not delivered fully in high end audio. More sadly, the transistor wormed its way into the record-making chain too early in its developmental process, and there are twenty years' worth of compromised recordings to prove it. Most sadly of all, so effective was the mass-media sell-in that it actually constituted a propagandistic aural re-education almost of brain-washing proportions, literally an "emperor's clothes" story: the public's hearing was influenced to change. "The *new* sound is the *right* sound; the *old* sound was the *wrong* sound!"

In case it started to happen when you were too young or you were old enough but didn't pay too much heed to the flim-flam of the indoctrination tales, we'll mention some (together with our irreverent comments):

"These new babies are small — like a cigarbox!" [We've never seen a forklift being used to lift a cigarbox.]

"These new babies run *coool*!" [Yet they need a noisy fan?]

"These new babies have no parts-availability problems; one part fits all!" [The transistor manuals and cross-refs are bigger than the New York phone directories.]

"These new babies don't have any nasty plug-in tubes!" [No; every one has to be soldered in by a technician *if* he can get the parts and *if* the repair won't cost more than the unit is worth.]

"These new babies don't cost so much!" [Pshaw! Sixteen Grand ain't all that much...]

Humour (black) aside, let us agree right off that in the non-audiophile sector, the price-point promise had the most validity; it still does in terms of value-for-money for average consumer music systems. For $300 or so, one can get a "rack-system" at discount stores which offer many features: stereo FM, record-player(?), cassette-deck, 30/40 watt amplifier(?) *two* loudspeakers plus a whole bunch of chipboard and glass doors... Music it is not; value it is, for average requirements.

Understandably, the manufacturers loved the low-cost and ease of building the transistor offered, particularly in countries where a low-priced labour force was eager to work. So the number of home systems proliferated, requiring even more records to be pressed, more recordings to be made in more and more new recording studios with an ever-growing list of artists and repertoire. But many of these artists were not exactly talents of the Sinatra/Segovia caliber, and often required days and weeks in the studio with expensive backing musicians. Monetary efficiency (who said 'greed'?) saw a potential saving in multi-track, multi-dub, multi-moneyed recording technology. The 8, 12, 16, 24, 32 and 48-track master tape-recorders were needed to hold an equivalent number of record amplifiers, playback amplifiers and bias oscillators; ditto the recording mixing consoles, which had to house crazy configurations like "64 IN/48 OUT".

Try feeding a tubed Neumann capacitor-microphone placed five feet from a good tenor *straight in without a pad* to one of these hundred-grand solid-state gems and you'll clip the first transistor to many percent of horrific distortion. These monsters had to contain hundreds of pre-amps and summing amplifiers. Were they built with tubes, they'd have had to be fifty feet wide! As it is, many are the consoles that stretch twelve feet in width, requiring 2 or 3 operators or (so much the better for equipment salesmen!) complicated computer-controlled mix-down consoles requiring *more* limiting, *more* de-essing and compression, *more* graphic equalization, *more* delay-channels, *more* noise-suppression...but never more music.

A greater number of master-discs had to be cut at greater speed; master-tapes had to be dubbed to second and third generation ("What azimuth problem? That's the master we have from France, and that's the master we'll cut!") multiple lathes running in tandem driven by rough-sounding solid-state amplifiers, often operated by night-shift part-timers.

And then came a breakthrough with real potential, though it hasn't always appeared so (except to the accountants!): Direct-To-Metal disc-mastering offered to OMIT one whole stage in the cutting-to-pressing process — the silvering of the lacquer to make an interim 'positive'. (In any positive to negative to positive-again chain, it is *very* desirable to leave out a whole generation.)

There have been a few pretty good DMM releases, and there have been many more that were not 'audiophile-quality' such as can be achieved via the best lacquers that have remained intact through processing. Then why hasn't DMM always been 'audiophile perfect'? Well, there are two reasons, both of which we're addressing.

First, the angle of the cut has to be around 50 degrees, which causes an oscillation or 'scream' (silent!) at 75/80 KHz. This is eliminated (or rather masked) by a clever 'Black Box' equaliser: we're doing a better one in the cleverer part of the circuit – the cutter-head's feed-back winding.

Second, the 500 Watt solid-state amplifier — it needs that much power (more actually) — to hammer that stylus into the copper... so we've designed a **1000 Watt Manley** amplifier especially for this – not that any audiophile who also wants 1000 Watts *times two for stereo* will be denied! However, the DMM lathes in use elsewhere are still driven by the original 500 Watt, crude-sounding solid-state amplifiers that come supplied with the lathe...

And one could easily observe the swing-over from quality to quantity in the record industry: when the long-playing record was introduced, it was aimed at people who cared enough to want quality music in their homes, cared enough to have an investment in the necessary equipment, cared enough to care for the records. At that time and up to even the mid-seventies, it was standard practice for record-company 'brass' to have a pretty damn good sound system in their offices and listening rooms; maybe not the quality-level of Infinity Beta's driven by our top-ranking amplifiers, but surely JBL's driven by Macs in the US, and Tannoys driven by Leaks in the UK.

And then it started to shift toward the numbers: "I'm not interested in how it sounds on a five-grand system — I'm interested in how it sounds on a fifty-buck car radio." *Sooo,* in addition to the main monitors in control-rooms, little tiny 4- or 5-inch speakers (mini-monitors) started to appear as the cross-reference. Then they became the *main* reference. "Will ya stop worrying, kid? If it sounds okay on these lil' babies it'll sound okay on anything!"

Long before it hit this all-time low, round about the entry of the multitrack tape machines, you can readily understand that the love of making the original recordings lost its joy for some of us. Prior to this period, we were going down from live-orchestra to two-track (or three or four) *tubed* tape-recorders, some with a mechanical transport-system approaching Swiss watchmaking standards that would make your eyes glisten just looking at them. Often, the tape recorder was straight-wired from tubed AKG or Neumann capacitor microphones (still regarded indisputedly as the best and worth ten and twenty times their original cost) and suspended/positioned in a Blumlein or Decca "tree" variant. Or, in the case of a line-level-only tape machine, the mikes would go via a good 20 to 40 dB tubed preamplifier (just like ours — yes, the circuits were pioneered and proved thuswise) or through a minimal mixer with maybe 6 dB of cut and lift using gold switches (yeah, we'd heard about gold then too) and, at EMI, with the most carefully-designed and monitored phase measuring and (passive) correction circuitry.

In this period of recording, you would have a set-up where the conductor and/or solo artistes would go to their side of the glass and do their utmost thing, comfortable in the knowledge that the engineer (often with a producer, though many times without) would be doing his utmost thing with the largest measure of good taste available. And when it was "thumbs up", it was committed to glorious two-track living stereo. After any editing and tidying up, the master-tape would go to the cutting-room for some trial lacquers to be cut through *tube* amplifiers running Class A or A1, and often of powers around only 50 to 100 watts. Yes, we pioneered our amplifier circuits in this mode too. More often than not, the first lacquers or trial pressings were carefully auditioned in the "brass" offices, comments noted and the lacquers re-cut with a different pitch or (miniscule) EQ until they were right — really right.

Lest you think we're rambling on here about the old days on the Ark, the answer is "no, my friend; we're talking about the records standardly being made in the sixties and even seventies, the ones that you admire most, the ones you're paying fifty, one hundred and more bucks for pristine copies of." The point being made here (obliquely, we must admit) is the sad tale that it's the audiophile whom the purveyors of recorded music initially address and try to win over with messages of promised quality, and it is the same audiophile whose desires for quality matter not one bloody jot when the magic-numbers pointer starts to swing.

If you're a nostalgia fan with a penchant for the bitter-sweet, let us go on (with a rueful smile!) to tell that some of us moved a little further away from pure audio toward the camera-side of motion-pictures, where the standard drill was breath-taking 35 mm Eastman Color Film exposed through Zeiss or Taylor-Hobson-Cooke lenses mounted in pin-registered cameras. And then came...Videotape! Transistorised pictures! *Aaarrrggghhh*!

After passing through a barren desert of depression (not being prepared to shoot videotape except with a three-eight Police Special smack through its multi-lined glass-facia) we pulled ourselves together and said: "Hang on, mate; something about quality has been learned in all this and surely there must be other souls who appreciate quality and won't settle for less than real quality." And so the idea came of putting some of the best circuits and design knowledge from the good recording period into amplifiers and preamplifiers destined for the playback of music in the homes of quality-conscious music-lovers. **Vacuum Tube Logic** was born.

Prototypes were brought to the USA in 1981 to see if anybody cared enough to order some. Regrettably, charlatans and dishonest souls (of the code "R" variety) exist in every field where glamour-with-profit is thought to lurk, and we met one who promised all, one who listened to 'cello sonatas all through the night, one who was visibly shaken to hear that a thirty watt amplifier could make a wonderful sound on Dahlquist speakers (not known for hyper-efficiency) one who ordered a whole raft of goodies and then went *ppfftt* and underground.

However, we'd survived transistorised sounds and pictures without falling totally apart, so we did another "pull yourself together, boy" sequence, put the amplifiers into small but professional production in Britain (where they enjoyed humble but appreciative results) and marketed them initially in Germany with great success. (They also care for quality over there, and have proven that with their motor-cars, to say nothing of Messrs. Bach, Beethoven, Brahms, Mahler, Mozart, Mendelsohn, Schubert, Schumann, Wagner; Incorporated).

Then in 1985 at the June CES show we gave it another shot in Chicago, and (not wanting to have another dreadful experience) we elected to distribute the line ourselves in the capable hands of family-member (son of tubes) Luke St. John Manley. It was obvious that Americans knew quality and that they wanted quality; taught us that the stuff has to be built extra-strong to withstand rigorous trans-continental shipping; and made us feel welcome. That was when we knew that **VTL** equipment had to be built (indeed, re-born) in the US of A.

First we assembled some models from British and American components and then we opened our full-production factory in California's "Inland Empire" — two years later with all **VTL** models on full stream, we launched the **Manley** range, Manley being our family name (we have continuously used it for custom professional studio equipment of all types).

Why a second brand at all? Was it really necessary? Yes. We believe **VTL** equipment is the finest value for money anywhere, at any pricepoint. We *want* it so; we want the customer to pay 'x' and feel he got a '2x' value, which is why we have not asked a price increase and don't plan one.

With **VTL** units we pour the lion's share of the production cost into the sonically audible components; very little is indulged for sheer cosmetic appearance. (No secret, eh? You have seen journalists' comments "...we're talking *serious* ugly here!") The fact is we *like* the minimalist, functional look of "open" tube amplifiers: form follows function, no?

So then, are we autocrats, dictators of public taste? No. We were also a little tired of certain people asserting that we didn't *know* how to design cosmetics.

So, for those folk who insist on visual as well as aural beauty, who prefer the "encased look" and who wish to pay for premium cosmetics, we proudly presented the **Manley** range; only we didn't confine the improvements to the visual.

We added electronic embellishments as well: extra power supplies, extra power, extra facilities — but still with the value-for-money theme never out of sight. Our **Manley 350 Watt** monoblocks are still less than two-thirds the price of our competition and sport milled panels and stainless steel finishes. Please pardon the commercial here, but we *are* proud of our insistence upon value-for-money and realise that we are somewhat old-fashioned in this view!

Another aspect of the **Manley** range is that we are supplying more and more equipment for studio and mastering applications. This gives us great satisfaction: to get the "good sound" in at the *beginning* of the whole story — the recording itself.

Industrial studio usage has another valuable side that won't escape the reader: as motor-racing experience benefits street cars in terms of innovation and toughness, so studio application of our *regular production equipment* proves out and helps us monitor reliability under the most stringent and demanding loads. We have 300-, 350-, and 500-Watt units (**VTL** and **Manley**) working twelve and sixteen hours per day, every day, at full tilt with nary a problem — hardly a tube change. Don't you agree that's good for us, and especially good for you from a reliability standpoint?

2

Measurements and The Sound of VTL Equipment

First and foremost, we at **VTL** are engineers, thoroughly trained in audio electronics. Our designer has spent a lifetime in the recording industry on three continents; the circuitry employed in **VTL** equipment has been tried, proven and improved in all positions of the recording chain. (The recording chain is almost exactly a complex stereo system from microphone (cartridge) to cutter-head (loudspeaker). Laboratory-bound engineers have to work and speak in the language of measurements ('measurespeak') but field engineers in music and recording soon realise that life outside the lab is somewhat different. Phenomena of musical instruments and acoustics seem to constantly remind us that measurements have to be tempered and balanced with experience and circumstances.

Most dyed-in-the-wool engineers and scientists think that musicians (and audiophiles in particular) are a bunch of crazies, yet they acknowledge that some talent is required is required to create music. When you get them steamed up enough these ones will resort to "If you can hear it, I can measure it..." at which point you could say "Then I suggest you begin by measuring a Stradivarius..." In fact one *could* measure a Strad in terms of output, constancy of volume of various notes and their respective harmonics; but the measurement would include a *human musician* (perish the thought!) and how could you be sure that he/she played both violins identically? With the same *feeling?* How does one measure feeling? At this point the scientist will start muttering obscenities and head for the bar...and you can go back to enjoying your music.

We take the view that while measurements are important — vitally so — the human ear has the final vote. We use our ears in the designing of amplifiers and our instruments to confirm what our ears tell us. There is no shortage of equipment of all types that 'trip the light fantastic' on the bench and sound bloody awful when a dose of music plus the sound of the human voice (speaking and singing) is applied. And it isn't only equipment: many is the number of times that architects and acoustic engineers have designed an auditorium or recording studio that measures superbly, but when the orchestra plays, when the actor softly speaks... We are often asked how and why **VTL** equipment sounds the way it does (truthfully, the question is most often put complimentarily as '...sounds so good...') Our answer starts "Well, tubes, of course", and then when pressed with "but tubes sound euphonic and, you know, like round and mellow", we have to go into some detail like explaining that the tube *itself* does not "sound mellow", that tubes have a linear frequency response to megahertz and beyond; that 'round and mellow' are kind words for a sloppy bottom and a decaying top.

We say that our circuit design is simplex rather than simple, complex rather than complicated. We explain about our transformers and power supplies. Then we go on to subtle things like component quality and that of wire, solder and layout. Very, very important are those matters. You may have noticed that the **VTL** products are fairly compact in size (well, for tube gear anyway) and the question arises as to whether we think that "small is beautiful". While not averse to saving space in general terms, the main reason is that compact layouts with shortest signal paths (little or no wire plus short, wide and thick copper traces) do contribute much to our sound. We also follow some old but oft forgotten rules like vertical positioning of output tubes (for better heat convection) and horizontal positioning for preamplifier tubes (for less 'shot effect' and better noise characteristics). Yet some of these design and construction techniques do not in themselves appear in the measurements. Or more correctly put, it is not obvious how the proximity of a given component to its important neighbour improves the performance. Besides the easy measurements like noise and distortion, the "speed" of **VTL** equipment amazes those who previously believed that only solid-state could produce speed and low frequency attack and our *kind* of attack. Our amplifier measurements are on the average around 22 volts per microsecond which, when taken in isolation, is not as quick as some of the most exotic solid-state circuitry, but then you have to look at the whole picture: the musical picture.

In the hi-fi world there are many examples that defy measurement: bi-wiring is one, fine interconnect cables another, the apparent loudness of tubes yet another.One of the most important aural phenomena we design and listen for is that of *imaging*. No measurement-unit exists to quantify this or spatial specificity/location. Hence our view that we, as audio designers, are akin to musical instrument makers. There is an art (as distinct from a science) to it and knowledgeable critics do not dispute this.

Where we side with the 'measure-speak' fraternity is in the instance of a piece of equipment which measures downright awful: we fail to be convinced that such an item could nonetheless "sound good" unless (remotely) perhaps it could be placed with other anomalous equipment whose deficiencies counter-balanced some of its inherent problems. And of course, the opposite example also exists in audio where two seemingly acceptable pieces of equipment have individual aberrations that conflict to highlight each other's faults. So again, measurements notwithstanding, we get to the art of selecting equipment that interfaces well and, oh so importantly, suits the room and the persons who occupy that room.

If you are into measurements, or wish to get into measurements of amplification equipment, we offer in the appendices some useful diagrams, such as an inverse RIAA network, plus the set-up connections, as well as a selection of oscillogram patterns; when fed a square-wave from a quality oscillator, the resultant square-wave on the 'scope often tells as much and sometimes more than row upon row of very high-tech numerals.

You might have noticed that we do not list specification numbers on our brochures: this is because we believe that they can mislead just as easily as they inform. Besides our own lab findings, we have had independent measurements taken of some of our equipment and have always been highly gratified with the results. Interestingly (and understandably to us) "their" measurements do not always coincide with ours. Our own measurements of our equipment seem to err on the conservative side, but the reason for the phrase 'understandably for us' is, as with individual home systems, that the test-bench gear and methodology is seldom replicable or identically calibrated. We include some of these findings for your interest in the appendices: the Fourier analysis of our **Compact 100 Watt** amplifier is totally stunning. But we still suggest that you *listen for yourself* and draw your own conclusions.

Reviews: Double Blind and Triple Dutch

A great deal of breast-beating, wailing and gnashing of teeth surrounds the whole topic of audio equipment reviews and the reviewers published in the audio press, and that's just from the manufacturers/designers! A large number of readers write in to the magazines complaining that the equipment most often reviewed is either too expensive or too cheap, that the reviewer is biased, that an impartial panel of blindfolded folk would give a more useful opinion... On the debate as regards cost and bias, we can only offer sympathy to the editors and publishers with the banal comment "well, you can't please all of the people all of the time". As to the "blind-panel" alternative, we have to come right out and state that we favour and believe in the objective (and, yes, subjective) review method every time: win, lose or draw.

Magazine readers sometimes complain that Reviewer A loved a certain component while Reviewer B liked it not at all, so how are they to reconcile these differing opinions? The answer here is that *both* reviews help one gain a better understanding of that component's good and bad points that may or may not suit your particular requirement. Like a second or third opinion in law or medicine (for which you pay dearly) it is up to you to sift the opinions of the reviewers with those of your dealer, and temper the mix with your own listening experience. Reviewers are human after all, and obviously will sometimes offer conflicting opinions: some people do not like the music of Bach, while others will tremble with joy just walking in the streets of His birthplace.

When one reads the reviews of our products, one cannot help but marvel at the sheer time in very careful listening sessions the reviewers put in; scrutineering, one should really term it. No casual plug-up, light-up, and say "yes, very nice, the best you can buy for $xxxx, etc. No, a very detailed report indeed listening to old records, new records, pop, jazz, classical orchestra and baroque. Very sincere, intensive and conscientious work. The adage to bear in mind is "Be guided, not decided."

Our policy has been (and will remain so) that in the main the 'name' reviewers are a sincere group of human beings who, though not infallible, are trying to pass on valid opinions and constructive criticism. If we think he or she is clearly wrong, we will up and say so and know that the publisher will give us the rebuttal space if our gripes are, in turn, valid and worthwhile. Some you win, some you lose and some just drive you insane (but only a little).

Let's look at the other side of the coin: that of the "double-blind" panel or individual listening tests with or without an 'ABX' switch-box, in which tha panel is played 'A', 'B', and 'X' and asked whetehr 'X' was in fact 'A' or 'B' (or neither; lots of trick questions are posed in double-blind methodology to make sure nobody is fooling anyone!) The ABX idea was conceived by an eminent engineer whom we respect highly; what he seeks to porove, and has done so on numerous occasions to the benefit of many products, is whether or not, when there really is *no* substantial difference between A and B, a panel (like a jury) can detect minor differences. Often they can't and a point of expense-rationale, say, is proven.

No doubt this system has great merit. However, we believe it is at its best in what one could honestly call mass-produced, average price-level, consumer-oriented products. We feel that true High End audio components fall into a category where adjudication by experts should be the ruling, as it is in many forms of endeavour: painting, sculpture, ballet, wine-tasting, gourmet cooking, book reviews, etc., etc. The list is endless.

Consider a symphony orchestra which proposes to appoint a new principal horn-player. Should they get the contenders to audition before a random panel? Rather, they should play for their conductor and possibly one or two other guest conductors whose opinion they value. If a concert-hall wishes to acquire a new grand piano, should they ask a committee, or ask some name-pianists and known-quality critics? Please!

Some members of a major broadcasting corporation overheard an "informal discussion" that was taking place at a convention about this. Outraged at the double-blind concept, they joined in and it became even more 'informal'! We, or course, took their side: when a piece of key equipment is being sought by a responsible body like a broadcasting authority or recording studio, *of course* only the opinions and ears of known experts (within or outside) will suffice.

We must go on record as stating that in areas of *true excellence* concerning the sound of music, we prefer the opinions of recognized experts. Call them (and us) "Golden Ears" in mocking terms if you like, but that is where it's at...and that is where it has always been.

3

The Human Ear

The human auditory system is an extremely sensitive device, able to detect miniscule sound pressure levels of air vibration as low as one ten thousand millionth of a centimetre, far outranking conventional measuring equipment. To compare the ear's extraordinary capability with the human eye, the equivalent in energy terms would require the eye to detect a 60 watt lightbulb at a distance of 3,000 miles in free air-space. The lowest level of audible sound is known as the 'threshold of hearing', such as the faintest rustle of leaves in an otherwise silent environment (we'll call that zero dB for these comparative purposes). The highest level humans can tolerate (before death) is known as the 'threshold of pain', which occurs at a sound pressure level of about 145 dB — the sound of a large jet engine at ten feet. The 'threshold of discomfort' lies at about 120 dB. The ratio between these extremes is on the order of 10,000,000,000,000 to 1! Because of these unwieldy numbers, information related to the auditory faculty is expressed in a logarithmic scale quantified in *decibels* abbreviated as dB [*see* DECIBEL TABLE in the Appendices].

Decibel measurements deal with the intensity or volume of a given sound, while the pitch, or note, is indicated by the frequency. This is the repetition rate of alternating air pressure changes in pulses per second, commonly expressed as 'cycles per second', nowadays more popularly called 'Hertz', abbreviated as Hz, or kHz for thousands of Hertz.

The theoretical frequency response of the human ear is taken as being 20 Hz to 20 kHz, but this varies considerably with age and sex as well as from person to person and 'condition' (health) and 'conditioning' to environmental experience. For example, a jungle inhabitant in his natural surroundings, whose ears have never been bombarded with jet-engine volumes, might well be able to clearly hear 20 Hz to 20 kHz, and possibly a little higher. Women seem to retain their upper-frequency limits longer than men of the same age; dogs have a very extended top-frequency hearing ability reputed to reach as high as 35 kHz and commonly to 25 kHz, which is the nominal frequency of those training-whistles humans cannot hear. Very probably this is why people have observed their dogs and cats leaving the room in distress at the sound of digital music. (Our dealers confirm that they have not been able to make a single digital sale to any of their canine clients; they prefer analogue but find turntables a little tricky to handle with paws.)

In more practical and average terms, human hearing is taken to be from 25 Hz to 15 kHz. The lowest fundamental note on a piano is 26.7667 Hz and the highest is 4,224 Hz on the Bosendorfer Imperial Grand. However, we have a 'feeling' of frequencies lower than 25 Hz, as experienced with extremely large pipe-organs, and also a 'sense' of frequencies above 15 or 16 kHz, as found in the harmonic structure of, say, a triangle. An intense pressure of about 4 pulses per second will cause the human sphincter muscle to collapse, and was very seriously researched in the closing years of World War II as a possible attack-and-disable weapon; whence cometh some crude expressions we have heard in low quarters.

The 'octave' of any note is double or half the frequency (2:1 ratio) and simple ratios exist between all the notes as in, say, the C-major scale where the fifth, G, has a ratio of 2:3; the fourth, F, a ratio of 3:4; the major third, E, a ratio of 4:5; and the major sixth, A, a ratio of 3:5. The fundamental notes in music are combined with the natural harmonics (also called overtones) of the notes as produced by the instrument/s to give us the pattern of the sounds we listen to. In nature there exists no pure single-frequency fundamental note; this is reserved for the test-bench oscillator which appears on the oscilloscope as a pure sine wave, or sinusoidal note.

The human ear can detect a harmonic presence of less than one tenth of one percent of the strength or amplitude of the fundamental note. It is the combined texture of the pitch, harmonic structure, timbre, attack and duration details that provide the 'aural colours' in life and music, enabling us to easily distinguish a single flute note from the identical note played by a clarinet. The 'timbre' is further defined by the natural resonance of the instrument (*i.e.*, the propensity to vibrate more readily at one particular frequency than another) and its 'transient' characteristics (the speed of the instruments' natural attack and decay).

All of these factors are in turn influenced by the acoustic properties of the space in which the sounds are being created: larger rooms tend to have longer reverberation (echo) times than smaller rooms, depending on the reflective (or non-reflective) properties of the walls, their angle of placement, as well as height, surface and angle of ceiling. Too, the proportion of height to width to length will affect room acoustics, as will the room's own resonances — often referred to as 'standing waves' in acoustic engineering. Take a drummer's 'rim-shot' or a wood-block. Was it played in a large hall or a small studio? Struck hard or merely close-miked and amplified? We can spot and label these subtle variants instantly simply because we have two ears (rather than the single microphone commonly used in measuring setups).

We can readily judge and keep in perspective volume, frequency, harmonics, transients, resonance, distance, direction and environment; be it Church or dead studio, concrete factory or open air. Traditional measuring equipment, confused by differences in environment, would confirm for example that a seemingly percussive sound of an approximate frequency at a stated dB level had appeared for a given duration. No measuring equipment can quantify a stereo system's imaging and soundstaging ability, or directional and lateral resolving detail. In the same way that a human ear can tell a Stradivarius from a hundred-dollar teaching violin, the experienced ear can judge loudspeaker quality and behaviour in a given room. However, the human ear is not totally 'linear' or 'flat', not having the ability to perceive all frequencies at exactly the same volume or intensity.

Measurements taken in an anechoic chamber (a totally 'dead' or absorptive room) of the loudspeaker will more specifically quantify its performance at given frequencies, thereby showing major inherent excesses (peaks, caused by resonance and other aberrations) or deficiencies (dips caused by driver and crossover 'suckout'). These read-outs, combined with the over-riding judgement of the ear, broadly define a loudspeaker's capability. Importantly, they will reveal and quantify basic technical parameters such as the impedance variation at different frequencies, minimum power requirement and maximum power handling ability and the unit's overall efficiency factor.

This latter information will be expressed in decibels (for volume) at one watt (of drive level) at one metre (the distance between the speaker under test and the measuring microphone). One watt is chosen mainly because the tweeters cannot withstand sustained single (sinusoidal) frequencies at more power for any length of time: the tweeter's voice-coil would overheat and burn out. This is a standard reference used throughout the world, and is fairly easy to understand. It is important to remember, though, that a loudspeaker's impedance is expressed as a 'nominal' value, which is taken at a reference standard of 1,000 Hz., and the impedance varies greatly with frequency: very low frequencies cause the impedance to drop to one ohm or less; high frequencies cause the impedance to rise to perhaps double and above the nominal specifications. This phenomenon of frequency-varying impedance has much to do with the overall interface of the loudspeaker to the amplifier's drive-power and their combined ability to deliver the volume required to a given room's acoustics and size. Planar (quasi-ribbon and electrostatic) speakers do not always yield the most informative information at 1 metre-1 watt (because of their large diaphragm area) so sometimes different volumes and distance details are stated. Electrostatic loudspeakers also exhibit *different* impedance/frequency measurements... often *decreasing* in impedance as frequency *rises*.

Loudspeakers

Loudspeakers, their types of design, inherent character and efficiency warrant some explanation. Any loudspeaker centers around a 'motor' of electro-magnetic or electrostatic principles. The motor causes the transducing diaphragm or membrane to move the air, thereby creating sound-waves, at a certain distance for a given amount of excitation voltage (the music via the amplifier).

Now, if this motor operation were to be of the regular electric rotating variety, we'd be talking of the motor's efficiency, predicated by its design and build, in terms of actual horse-power produced from the amount of electrical energy required. One horsepower is related to 750 watts of electricity, so if the motor under test only produced a half-horsepower from 750 watts, it would be deemed to be 50% efficient: not the best, but more efficient than any loudspeaker. We don't use percentage to relate to loudspeaker efficiency (except discount!) preferring instead to quantify the sound level produced by one watt at one meter. Hence the statement "...such and such loudspeaker's efficiency (or sensitivity) was measured to be 84 dB/1 W/1 m..." Let us examine some of the various technologies employed in the basic 'motors' or drive-units themselves.

Cone-type Moving-Coil or 'Dynamic' Drivers

These are by far the longest in service (and therefore in development). This is the most commonly used system for reasons of efficiency against the manufacturing cost. While seeming to be a very simple magnetic device, the cone driver is a complex design which involves electrical, mechanical and acoustical disciplines. In essence, a coil (the 'voice-coil') is wound around a cylinder or tube attached to the inner diameter of the cone. The outer diameter of the cone is attached by a flexible suspension to a mounting-frame or 'basket', as is the throat assembly with its attached voice-coil, so as to enable it to move forward and backward in a piston-like motion. Inside the voice-coil is a magnetic pole-piece which is attached to the heart of the motor, the main magnet that surrounds the assembly. The connection of electrical energy to the coil causes the cone to move back and forth in the magnetic field, thereby moving air and 'transducing' the electrical energy to audible acoustic excitation. Here is where the efficiency factor depends upon:

a) The strength, size and quality of the magnet (expressed in Gauss-units of flux-density, weight and the composition of the magnet). When the magnet is very large in strength and size, as is not uncommonly found in drivers capable of handling high power, there is an interaction of 'magnetic-braking' known as 'hysteresis effect': this dampens the cone movement, and thereby retards "speed" and curtails "highs".

b) The gap-size between pole-piece and voice-coil.

c) The 'cold' resistance of the coil-winding, dependent on length, its thickness and type of material (copper, silver, aluminium) plus its shape (round, square, rectangular etc.)

d) The size and mass of the cone.

e) The cone's composition and flexure characteristics. Cones have been made from paper, acrylics and mylars, treated cloth, aluminium and recently such 'wonder' materials like "Kevlar" — a woven and chemically-treated fabric.

f) The cone's mechanical resistance to being pushed in and out together with...

g) Its recovery time.

h) Its 'air-load' both against its own cabinet and the driven acoustic.

i) Its own resonance or 'Q' factor, coupled with that of the enclosure. ('Q' of a resonance is broadly defined by its magnitude; in order to produce a distinct note, the value of 'Q' must be greater than 1 — a wineglass may have a 'Q' of up to 100 and a loudspeaker enclosure should be completely dead with a negligible 'Q' factor. This is why they are made from very dense composition-board rather than raw timber planking which has a higher 'Q' or, say, sheet-metal with an unusably higher 'Q' yet.

j) The total combination of all these variables culminate in the overall 'damping-factor' a number which is inversely proportional to 'Q'.

k) And then the unit's intended frequency coverage, which will in turn dictate its impedance and how it varies. The design of the essential enclosure obviously plays an important part; were the bare driver to be connected to an amplifier, there would be virtually no low-end response nor any power-handling capability; this is primarily caused by the front-to-back cancellation effect of the bass notes. Merely fitting the drive unit to the centre of a large flat board about twenty times the drivers' size, called an "Infinite Baffle", starts to correct cancellation, but does not do much for balancing resonances nor give the driver optimum loading to produce good bass.

The first problem of a cone driver's frequency response occurs with its size and type: big, heavy and well-damped designs yield good bass with high power-handling but poor mids and treble. Light and fast attributes offer the mid and top but cannot produce any bass with power. Hence the commonly adopted dual or triple driver system, with each driver being dedicated to a portion of the frequency spectrum.

Enter new cans of worms: the crossover network and the arrival times of the different frequencies. The crossover divides and allocates the spectrum to the various drivers and should also seek to equalise their inherently disparate efficiencies, exacerbated by 'speed' or transient response. Phase shift may occur in the crossover, which will require correction in the vertical placement-line of the drivers to realign or optimise time-arrival (possible delay) and these factors are combined with the electro-acoustical properties of the enclosure itself. The enclosure can be designed according to many possible concepts and can assume various proportions and sizes, all affecting overall performance. A smoothly integrated three-way crossover system is a rare beast indeed, requiring hefty calculations and much adjustment by ear. Richard Vandersteen builds some of the best.

The Dome Tweeter

This is the most commonly employed unit designed to handle the treble frequencies. It is similar to the cone driver in concept, the difference being that a little dome or half-sphere of about three-quarters to one inch diameter is attached to the mouth of the voice-coil cylinder. The dome-shape is chosen for its smooth dispersal of high frequency information and the material of the dome varies from compressed paper to doped cloth fabric to fine metals such as aluminium, beryllium and titanium. The different materials impart their own sonic characters and 'speed' or rise-time. Dome-tweeters do not need the size of magnet commonly found on larger drivers, since they do not handle such low frequencies or as much power.

A small-cone or larger-dome variety of driver (which is a very small bass unit or an oversized tweeter, depending on how you look at it) is often used as the mid-frequency driver. This was lovingly (and dead accurately) dubbed the "squawker" by older American audiophiles, who also coined the name "woofer" for the bass driver. Just one of the problems encountered in the design of a three-way unit to include a mid-range squawker is that the human ear is not, as already mentioned, all that linear; it is around the frequencies between 1000 and 4000 Hz that the ear peaks in sensitivity by up to seven or eight dB, thereby highlighting the squawker's potential to squawk. Purists (and we certainly choose to be among them) preferring instead the two-way system with a 'more seamless' transition from the bass unit to the tweeter. Of course, a single full-frequency driver would overcome all crossover vicissitudes and would seem to be the ideal solution. Yet like many ideal concepts, the problem of sheer physics stands defiantly in the way.

An older design comes to mind from the Lowther factory in Britain. Because it is light and fast enough for the upper frequencies, its power handling is limited. Being of only six inches in diameteron its own, it requires a pretty complex labyrinth enclosure to produce good bass; but smooth and homogenous? Very. Efficient? And then some: about 96 dBs worth, so that a very convincing sound indeed can be achieved with a sanely-operated 25 watt amplifier of high quality. We enjoy very pleasing results with three Lowthers handling almost the whole frequency range, augmenting them at 12 kHz with a super-tweeter on top and under-pinning the bass with the superb Hartley 24-inch woofer. We routinely supply these to mastering and mix-down rooms for hyper-accurate semi-nearfield monitoring. [See **Manley** brochure.]

While on matters British and some of their clever and efficient designs, it is perhaps worth mentioning the cone-driver designs of that acoustic titan, Edward Jordan. Jordan probably knows more about cone drivers than any other living person, having devoted a lifetime to their design and manufacture. He believes in aluminium cones, both treble and bass in a two-way system, for their lightness (speed) and properties of flexure, among other factors. Jordan's loudspeakers have to be heard rather than described: we would go as far as to say they are, with some German Kevlar drivers we have heard, the leading edge of cone-technology available today.

Horn and Pure Ribbon Tweeters

These are two of the other options available to loudspeaker designers using two or more drivers. Horn tweeters (and mid units) are essentially tiny diaphragm units not unlike that of a dynamic microphone, and is enclosed in a magnetic field of considerable proportions under unvented or pressure conditions. This diaphragm is positioned in the throat of a trumpet-horn (to give it even more efficiency) and is sometimes utilised with a re-entrant or labyrinth design to enable it to go lower and louder. Horns are not popular in today's audio world as the result their tendency to 'shout' at the listener; it is not for nothing that horn systems are used at baseball diamonds and railway stations! For all that, when a horn tweeter is well designed, constructed and smoothly crossed-over with an excellent bass system, some very pleasing results can be achieved.

Some of the older American twelve- and fifteen-inch cone drivers employed centre-mounted pressure horns (Lansing, JBL, Altec) and were efficient to the tune of 100 dB. They still find much favour in the Japanese marketplace, often being driven by Class A amplifiers of 4 to 8 watts of power. We find this very interesting, and conclude that the horn's inherent clarity plus the fact that traditional Japanese music does not have vast low-frequency content combines in a way they like. Not to mention the famous American acoustician, Paul Klipsch (and his well-loved Klipschorn) would be both rude and unfair. You hardly ever see Klipschorns written about in the press, and we think that this is a pity. The units are in abundant production in three or four sizes up to the 'killer' unit with its absolutely excellent labyrinth enclosure for the bass; it produces a quality of bass that is hardly equalled, let alone beaten. Too, it should be stressed that the bass-labyrinth enclosure couples very favourably with the room acoustics, whereas the fairly common "sealed-box" enclosure battles, to a large extent, the natural acoustics.

We need to make a distinction between 'pure' ribbons and 'quasi-ribbon' units, as we shall explain. Pure ribbons only exist as tweeters in the sense of a crenellated foil ribbon hanging in space, suspended at top and bottom, within the cheeks of a powerful magnet. In essence they are a near-replica in shape and size of the classic ribbon microphone (such as the RCA 44B. Stanley Kelly designed some tweeters of this type for Decca London, and in more recent times the justly-famed Magnepan Corporation has offered a winner of a long-dimensioned (40 inches or so) pure ribbon tweeter which goes far lower than Mr. Kelly's designs and are, because of their length, easy to drive. Kelly's ribbon itself was only two and a half-inches long, easily four inches or so if you stretched and destroyed the accordion-like crenellated folds. This meant that the DC resistance of the foil was akin to a paper-clip (*i.e.,* about one-fifth or near-zero ohms) and could not be driven at all without a transformer. Subject transformer had a secondary of negligible impedance to face the ribbon being wound from about ten inches of rectangular or flattened copper section of about 6 or 8 gauge. The primary was wound to eight or ten ohms nominal to face the crossover. A daunting design and execution, but nonetheless one capable of very seductive high frequencies.

Quasi-Ribbon Speakers

These units are comprised in the main of a section of foil attached with adhesive to a diaphragm or planar membrane with a bar-like magnet-structure being placed in front or in rear (or both) close up to the diaphragm. These units are usually full-range. Because of (again) the resistance or impedance of the foil being on the low side (one, two or three ohms) along with the magnets being inherently less-powerful, they are often what is termed 'hard to drive' and classed as being somewhat less than efficient: from around 70 to 80 dB. The leading brand offering this style of technology is Apogee, and they certainly have their following. We hasten to point out that when Apogees appeared on the market place we took cognizance of their likely admirers and re-designed our output transformers to offer a 1.85 Ω total-secondary configuration (optionally adjusted) to drive such loudspeakers. We believe that we are the only tube-amplifier manufacturers who offer a unit that can properly drive the quasi-ribbons — and *we do mean 'properly'.*

Magnepan's Magneplanar loudspeakers (other than their ribbon tweeter as already mentioned) fall, in our opinion, under a different classification all by themselves, for they are not quasi-ribbons. James Winey's unique design utilises a *wire* coil of lightweight aluminium and, having a resistance of around five ohms, they are easy to drive and reasonably efficient at (82 to 86 dB approximately, depending upon the model) and moreover present a hardly-varying near-constant impedance load to any amplifier — a most desirable design criterion. We class Magnepans as innovatively different but nonetheless essentially 'moving coil' loudspeakers of a very high and musically accurate caliber.

Returning to the quasi-ribbons, it must be noted that there is yet another technology for applying the ribbon to the membrane: that is the deposition type where the 'foil' or conductor is electro-deposited in a plating-like process. Bruce Thigpens' "Eminent Technology" design is built in this way, but the best known of these is undoubtedly the Emit and Emim units offered in the Infinity range of loudspeakers. Recent development has yielded larger and lower-frequency capable drivers that have emerged on the market as "Gammas" and "Betas" and (gulping for words and breath here) what loudspeakers they are! The Beta is a much less-expensive and (mercifully) less space-consuming reference system unit than the awesomely excellent IRS giant-towers, which cost a great deal more, and worth every cent of it. You sold your house to buy those speakers? Well done, mate! Nudell, Miller, King and team have produced again what will be used as "the reference" and the only problem seems to be that the news is out and too many audiophiles want them. But, having heard them, let us tell you that the agony of being on a wait-list will be very well rewarded.

Electrostatic Loudspeakers

These planar-styled units (and the deliciously enigmatic units that they are!) are in a category all by themselves because they have 'motors' of a unique and non-magnetic principle involving the static-charging or polarisation of a di-electric membrane. Why enigmatic? Well, rather than offering a frequency-varying impedance load to the driving amplifier, they additionally introduce another element altogether, in the form of capacitance. In fact, charged capacitance is the key to the discipline within which they operate. All ESL (for Electro-Static Loudspeaker) units require to be plugged into the household mains to energise their built-in power-supply. They must convert this AC mains voltage to extremely high DC voltage (though at very tiny current, like the sparking-system of a combustion engine) on the order of eight to twelve thousand volts. This is the polarising rail between the anode and cathodes (membranes) of the system.

The British company Acoustical Quad Ltd. (who recently celebrated their fiftieth anniversary in audio) were undoubtedly the forerunners in this well-proven technology. Their original "firescreen" model had been selling well all over the world for nearly thirty years before they introduced the newer ESL 63 model (and variations) about ten years ago. The Quads were always an 'easy drive', and in fact the first model was not able to handle much more than 15 or so watts, being offered as it was with the classic Quad II tube amplifier. Many of those early Quads are still in use, and are even preferred by some over the newer models for their ultra-smooth natural mids. Bass was never one of their outstanding virtues but the bass it produced, though gentle, was very clean and accurate. The later ESL 63 offered more and better bass as well as better dispersal and time-alignment; in American-designed mounting stands they are a very musically satisfying loudspeaker, moreso when driven by **VTL** amplifiers.

Coming to well-deserved prominence in the latter couple of years is the name Martin Logan. Their CLS (pure 'static, without cone hybridization in the bass) is a gorgeous-looking, as well as fine sounding, consummate piece of design and engineering. Easy to drive, these units are the musicologist's loudspeakers rather than the 'heavy-metal brigades': pounding bass they do not offer; smooth musical accuracy they definitely do.

Other than Martin Logan and Quad, there are a few other ESL's available, all having their own particular merits. The big Soundlab A1's are regarded by many as the reference ESL of large size. Acoustat offers several models ranging from a tall thin sculpture-like piece to a cone-augmented heavyweight. The Dutch firm Audiostatic, headed by designer Ben Peters, make a neat little guy about four foot high and also a big fellow standing some seven foot high. Very few have been seen or heard in the USA, however. The Canadian firm of Dayton-Wright made some close-to-square units, wherein the sound-driving membrane operated in a gas-filled space; very impressive-sounding units they were too. In any event, the electrostatic loudspeaker is a well-developed and stable technology that has many admirers almost always attracted by their subtle smoothness.

The whole picture of loudspeakers then would seem to divide broadly into two main headings (with some variations admittedly): the box/cabinet type using cones, and the flat/planar. These use various technologies. The variations mentioned above in the box category include transmission-line and labyrinth enclosures as well as very efficient essentially two-way but multi-driver units like the big Kindels. The planars are the newer technology in the flatter, often bi-radiating style. We get asked all the time which loudspeakers we really prefer and we have the answer ready right now: the loudspeakers we favour are the ones that a) suit the room best; b) suit the owners musical tastes best; and c) suit the amplifiers' power best. To this must be added the matters of affordability and decor of the (usually) multi-usage room.

Certain distinctions become very clear, again broadly speaking: cone or dynamic speakers often sound more, well, dynamic! This is especially true when cost is a factor. They are able to produce deep and stirring bass, whereas planars tend to produce a more real kind of music. (It depends though, doesn't it? If one were a bass-player in a rock band standing in front of his speakers, then cone-bass *is* the real bass, no?)

Planar speakers will always produce less thunderous bass, but with better imaging attributable to both their slimness and bi-radiational pattern of dispersal; for the self-same reasons they are somewhat harder to position in the room. We should probably 'fess up and say that bipolar radiating types are our first choice, mainly because we get so much enjoyment out of the imaging and sound-stage realism.

Then again, our tastes are not necessarily the same for everybody, and there really seems to be no *one* louspeaker that is universally loved with no reservations. The design of this piece would seem to be the Holy Grail of audio. When we have elected to use a given speaker at shows, almost without exception there have been a couple of folks who have commented "Well, I would never have chosen *those* speakers!!!" To this we have replied: "So what type *would* you have chosen?" — and been able to mount good reasons (for show purposes) why some of the suggested pieces would not have been as suitable.

We're always hard at work on new projects and often in the control-room monitor-speaker arena (an admittedly specialised-end use). Who knows? Our **Manley Reference** control-room monitor may find favour in the audiophile's home, too.

And what of sub-woofers in general? This we regard as a matter of personal preference; if your musical tastes run the gamut of Buxtehude's pipe-organ to Bruce Springsteen and your enjoyment is heightened by not just hearing the bass, but feeling it enter through the soles of your feet, then John Marovskis is your man!

In the summary of drive systems we left out the "Plasma-gas" tweeters deliberately; they are not often used nowadays, being even more esoteric than tubes themselves [and we couldn't have that, could we?]

Room Acoustics

Room acoustics and the discipline of acoustic engineering is a major subject that goes far beyond the scope of this little book. Sadly, even students of architecture are only given a somewhat cursory sampling of the principles and theory involved. Consequently, in average house and apartment design, room acoustics rarely, if ever, enter the planning and design specifications. Understandably, matters of space-utilization and cost take precedence. The question of keeping intrusive outside noise from entering the living environment is also often overlooked, more's the pity. A small quantity of homes are designed and purpose-built wherein the owner requests that the architect include a music-orientated study or listening room — but those are in the minority.

We believe that High End stereo equipment must be able to produce a very accurate and easy-sounding illusion (for that is what it is) of live music in typical and average domestic living rooms; also the 'look' of the stereo equipment should not invade and dominate the given room. We, like most manufacturers, exhibit and demonstrate our equipment at hi-fi (we hate that word) expo's where hotel rooms constitute the available listening areas. We always make a point of setting up the room as it is offered to us, that is without deploying large sheets of acoustic foam, low-frequency traps or other sound-absorbing treatment; this enforces the same constraint in situating the loudspeakers in positions that an average family person might have to accept for a multi-usage room, warts and all. We know of meter-wielding loudspeaker designers who rush about the room measuring reflective readings and 'lobe-areas' and sobbing "My beautiful speakers can never produce a good sound in this lousy room!" to which we can only comment "yeah, yeah" and point out that nobody we know lives in an anechoic chamber, and that almost every purchaser of his speakers will need to enjoy them in a less than perfect room. We go further to spell out that the room and the choice of speakers chosen for it is the major unknown factor for all manufacturers of all kinds of musical reproduction equipment.

We believe that besides acoustic matters, the selection and placement of loudspeakers, for instance, should not destroy the decor. Sure, if you are a dedicated afficionado of music, you will probably plan the room to reflect this. But if you should force your way to choosing loudspeakers whose looks and size are absolutely *hated* by your spouse, then rest assured, you will not derive much musical pleasure.

Before even thinking of the loudspeakers, bear in mind that there are basically three sizes or concepts of systems — you guessed it — small, medium, and large. All have their valid places (poetry, yet) in various spaces.

The small system takes its roots from Europe or anywhere where the people have lesser-sized rooms; London 'bed-sits' jump to mind. Though we personally do not favour mini- or micro-monitors, they *do* have their place. What's a chap to do? Break his lease by infuriating neighbours? No; he sets up a smaller system which is pretty damn accurate and truly High End (with perhaps a little curbing of big bass) and produces a smaller, but coherently-scaled sound stage. We have heard excellent systems like this, even though (no offense intended) the "Anvil Chorus" seems like smaller people are striking smaller anvils!

The medium system is probably what most audiophiles own and enjoy. . .average to larger-sized room, shared with the family and maybe built around 100 to 200 Watts. No doubt the widest choice of loudspeakers are available in this category. Box-style, planars, ELS, they're in there.

The large system is reserved, we believe, for much larger rooms with the oft-accompanying availability of purchasing-power. Here the sought-after goal is to really go for the 'concert-realism' concept: huge, life-like stage, high power, *big* speakers, 300 to 500 (and 1000) Watts per channel; they sky (and the room) is the limit! This is where you'll find the Wilson Whamms, Magnepan Tympanis, augmented perhaps with Janis subwoofers, the Infinity IRS's. . . truly, the 'recreated concert-hall' domain. *However,* not having the room or the money to fill it with this type of equipment should not deter you from getting the best, most musically accurate sound you can in the room you have with the kind of money you can afford! That's where a lot of the fun and personal satisfaction lies, often given over to a consultant or interior-designer by the mega-buck folk.

There really is such a phenomenon as overloading an acoustic space or volume; have you ever heard a very large piano (nine foot concert-grand for example) in too-small a room? If not, please let us assure you that it is extremely loud, uncomfortably so. Further and strangely, it tends to produce acoustic aberrations not dissimilar to 'wow-like' pitch variations that can normally be produced only by variations in mechanical speed. Listening at volumes that are uncomfortably loud is the dead giveaway of a greenhorn. Music is not meant to be like that. When you play the Berlin Philharmonic in your living-room, do not dream that you could or should try to emulate their volume. We are dealing with an illusionary and scaled-down picture of a huge orchestra in your home; certainly it is obvious that one could not even accommodate the trumpet section in terms of floor-space alone, but more importantly in terms of acoustic overload.

We realise that one cannot make over a family lounge in the way one might a studio; but you could try to aim for the L.E.D.E. kind of thinking. Those initials stand for Live End Dead End, wherein the loudspeakers are placed in the acoustically more dead end of the room; you may have to partly create this by positioning drapes, wall-hanging khelim rugs or decorative screens at this end; and by ensuring that the speakers go on the carpet if the room is not fully carpeted. You can also be aware of and try to 'break up' large reflective surfaces with drops of drapes or, again, little decorative rugs or quilts that serve the purpose of enhancing the decor and the acoustic.

The most creative thing one can do, however, is to choose speakers that work well in the room. If planar speakers sound the way you want only when placed in a grotesque and uncomfortable position, then you ought to consider another kind of speaker. If box-type speakers exhibit 'boom', no matter where they're positioned (possibly due to the squarish proportions of the room) then perhaps they're not the best choice. We presume that it is known that 'box-types' increase their bass output dramatically when placed in or near 90 degree angles such as near floor-wall corners or the actual wall-corners themselves which, with the floor, make *three* 90 degree surfaces.

Though not truly a matter of acoustics, nor even of psycho-acoustics in the common meaning, we would like to close this short chapter on a note of inter-spousal good relations; let us call it 'psychological engineering': we feel that a fair amount of the reputed animosity that women are (dis)credited for harbouring against stereo music comes from her being excluded from the choice of equipment and/or being over-ridden when she is ostensibly invited to contribute her feelings to the choosing of equipment. Music is a world language, not just a male language. It should be shared and enjoyed. Another thing we learned long ago and take as valid fact is that women do have a sensitive hearing system, often moreso than men. This is not just birthright; it has to do with conditioning experience as well. Probably because men spend more of their lives in noisier environments most likely encountered in their careers: factories, workshops, shipyards spring to mind.

So when a woman asks to have the volume turned down (not just to talk over, of course) we tend to feel she has a (pretty) sane grip on things. Too, she will ask for less volume if the amplification system is distorting in any way: the solution here, we're forced to admit, is to listen through tubed equipment, preferably ours.

Power and Noise

This section is specifically about amplifier output power and should be read in conjunction with "Loudspeakers and Rooms". First, let us realise that all amplifier power specifications are given based on measurements and calculations [*see* "Formulæ and Tables] when the unit is driving a resistor of a *fixed* value. This is by no means an ideal reference, but at least it is pretty well standard, and all manufacturers quote it. The problem is that loudspeakers do not measure like a resistor, nor behave like a resistor. Nor do our ears, neither do our rooms.

The volume of your room will affect the power the loudspeaker will require to drive it and also, by association, whether the loudspeaker itself can handle the power that the room and listener requires. When the oft-asked question "Will the XX watt amplifier 'blow' my speakers?" arises, it is interesting to note that an excess of clean amplifier power blows far fewer speakers than the multitudes of speakers blown by *under*-powered amps that have been pushed up in volume past 'clip' and even into square-waving. This is more common, so sorry, with solid-state amplifiers. And yes, it is not impossible to destroy, say, a 50 watt-capable loudspeaker with a 200 watt (tube even) amplifier, but you have to really work at it. When cranking up bass and/or treble controls, where fitted, (thankfully not common and not necessary on High End equipment) it is well to remember that one is turning up the amplifier volume at the frequencies affected. Nothing, save supersonic oscillation, is guaranteed to make a tweeter smoke faster than horrendous amplifier-clipping at high frequencies.

"In-car Sound" is not one of the subjects included in this treatise, but we just have to smile and shake our heads at the known early-demise of sundry car-speakers which serve to illustrate our point. Often the car installation includes an underpowered amplifier in tandem with a so-called "graphic equaliser" — the fellow cranks up the 4, 6, 8, 10 and 12 K doo-dats, plus of course the 40 and 80 Hz ones for good measure. Finally the little speakers, loaded only by the door-cavity, shriek, fart and die with perhaps the cones becoming detached from their mountings. Then the sad fellow has to have his doors dug up and mutilated some more and *pay* for the privilege. Now that's what we call *graphic.*

So then, how much or how little amplifier power is going to be right for you? One obvious answer is that it is better to have too much than too little, both from the viewpoint of good sound and possible later loudspeaker up-grades. One rule of thumb is that if you, or a knowledgeable invited adviser, vaguely suspect you're running out of power, then you probably are. Even highly experienced audio buffs can be fooled into wrong decisions by a shortfall in power.

A philosophy often expounded by one of America's well-loved Motoring Correspondents, Tom McCahill, was "Remember, there is no substitute for cubic inches!" Horsepower, he meant. But horsepower is a linear measurement, like dollars, and audio power is a little harder to equate being logarithmic in scale; so doubling amplifier power from, say 50 watts to 100 is an increase of only 3 dB and doubling yet again to 200 watts is an additional 3 dB, making a total of 6 dB. So in theory a 50 watt amplifier driving a 90 dB efficient speaker should "go loud" to be the same as a 200 watt amplifier driving an 84 dB speaker. In practice this is very hard to demonstrate, because one would need identical-sounding 50 and 200 watt amplifiers (we can provide this) *plus* identical-sounding loudspeakers of 90 and 84 dB efficiency, but they'd also need to be exactly matched in terms of cone size and shape, cone material, speed and suspension, frequency response, flux density, impedance and weight, all of which is impractical (nay, impossible) to execute. Notwithstanding the aforegoing mathematics, we know that one can always "hear power" in the form of transients (rise-time); solid, powerful bass simultaneous with delicate flute figures (intermodulation distortion) and the overall effect of effortlessness that only an elegant sufficiency of power produces.

So why, you may well ask, does **VTL** build 45/45 and 75/75 watt stereo amplifiers? The answer is that 45 watts is one hell of a lot of power, in an average-sized room driving relatively efficient loudspeakers to relatively sane volume levels. The operative words here being 'relatively' and 'sane': Einstein was an expert on the former, and we know a little about the latter. When Gilbert Briggs of Wharfedale was promoting hi-fi as a hobby back in the fifties, he was fond of saying (and this was mono!) "A good 10 watt amplifier driving efficient loudspeakers such as mine will fill a concert-hall." He was talking about tube amplifiers (which always seem to be audibly more powerful than the equivalent solid-state device, much like 25 watts of pure Class A power dwarfs 25 watts of Class B power) and loudspeakers of 96 dB efficiency; for 'fill' you could probably substitute 'be clearly heard'.

Other examples are the amount of power used in a four-wall cinema during an average drama film (20 watts peak; *please,* no canonshots!) and the way some Japanese afficionados use 8 watt single-ended Class A tube amplifiers for total audio bliss. The keys here are that both the 8 watt audiophile and the movie-house are using hyper-efficient loudspeakers (possibly in excess of 100 dB/1 meter/1 watt and certainly 'horns') plus — and this is important — they are in a low ambient-noise environment: no talking while the movie is playing, right?

The matter of a noisy environment has a lot to do with your power needs and, of course, how much your power/volume will increase your neighbours' environmental noise. It's interesting to contemplate a Japanese house with its fabled paper walls, the people in the room adjacent to the 8 watt audiophile might be talking quite loudly to be heard above the accurately reproduced Koto music; this irritating chatter will distress the 'phile, who will promptly turn up his volume, the better to hear his Class A Koto, thereby compelling the now-shouting folks next-door to yell louder, which will make the 'phile again reach for his volume-control (as his eyes involuntarily dart to the ceremonial Samurai sword adorning his wall).

The point of that little scene is that 45 watts per channel (that's 90 watts potential total) would do very nicely driving, say, the large Kindel speakers in a room of, say, 12 by 18 feet in a reasonably quiet environment, such as a typical home in a residential area. But that same system would almost certainly be lacking in power if that room was in a second-floor apartment with a window near the Chicago "EL" railroad. To ensure that the system was not heard *at all* when the "EL" was passing, you would only have to replace the Kindel speakers with some 83 dB Magnepans still driven from the same 45 watt amplifier. And then again to ensure that the system could be heard properly as the "EL" roared by, you would need a 500 watt amplifier driving a very efficient theatre horn-system or a sound re-inforcement system such as favoured by "The Grateful Dead" in concert plus, of course, a large supply of analgesics to combat The Threshold of Pain.

Let us go from these extreme (and somewhat exaggerated for illustrative purposes) examples we move to another real, and not uncommon, scenario where the 45/45-based system is located in an unusually quiet location with virtually zero ambient noise [yes, such places do exist for some fortunate folk living in farmhouses or other country locations]. We have many **VTL** clients in such situations, but two exceptional cases spring to mind: one is a conservationist in the heart of the Black Forest, Germany, and the other is a pipeline engineer in the extreme North tundra of Norway. Now the problem of competing with the noise of the "EL" swings to one of competing with the absolute silence! Which is to say that any residual back-ground noise like hiss, hum and mechanical buzz (from transformers and turntable drives) are clearly audible and severely intrude on the music — worst, of course, in the quieter passages. The importance of silence in the whole audio chain is one, we feel, which is not highlighted enough.

Most enthusiasts are constantly trying to get "extra sounds" into their system: more or tighter bass, top extension, better imaging and so on. However, we feel that one tends to overlook the the importance of getting spurious noise out. You may scarcely believe what improvements in imaging, staging and lateral information can be achieved by engineering out the white noise, pink noise, hum, buzz and other crud. Remember, much of this muck is amplified and modulated by the electronics.

We have done a fair amount of charitable design and supply work for tape-duplicating facilities specialising in multi-copying of books on to tape for Blind people, and from this experience we learned much about the intrusive aspects of spurious noise. Interestingly (and pretty obvious when you think about it) because the blind have poor or no vision, they commonly have an acutely developed sense of hearing. Experiments to find out which forms of programme pollution disturbed them most revealed that spurious noise far outranked other forms of distortion. Again interestingly, intermodulation distortion bothered them more than harmonic distortion; it is a fact that even normal listeners cannot aurally detect harmonic distortion under three percent, but we found that figure could be less than halved for our blind friends. Because of the noise factor, it is easy to understand why Compact Discs are very well liked by blind folk, and the ease of handling of CD is a boon to them.

Returning to our Tundra and Forest clients ('friends' is a better word) — both of them use our **Ultimate** preamplifier with our **deLUXE 100**'s driving, co-incidentally, Quad ESL63's; and, no, we won't go into whether they prefer CD to LP. Oh, alright! One does and one doesn't...but the one favouring LP's has an enviable collection going back thirty years and all kept in mint condition.

(We're coercing him to will them to us and are already scheming a nasty accident involving avalanches and monster ice-cracks.)

In summing up on power then, let us agree that the choice of amplifier power is very related to loudspeaker efficiency, and the sound levels you personally want to achieve but that more power beats less power every time. Only sordid matters of space and budget will constrain the decision.

Bi-Amplifying and even Tri-Amplifying

This is senior-league audiophile territory worth knowing about, we feel, even if one is only toying with the idea of venturing into it. The concept of having separate amplifiers to do separate jobs is simply just that: to divide the frequency spectrum (in a similar fashion as occurs in a speaker crossover) so that each amplifier is dedicated to handling only its pre-ordained portion. The benefits seem obvious, not the least of which is being able to use a lesser-powered and optimally-chosen amplifier for, say, the treble.

A common practice, which we really do not recommend as we'll explain, is to mis-use this scheme with a readily available technique which could be called "Instant Bi-Amp" or "Fool's Bi-Amp" (as per the 'fool' in Chess). This involves using two, say, amplifiers to drive a loudspeaker which is "Bi-Wire-ready": *i.e.*, the speaker manufacturer has offered separate terminals for accessing the bass and treble sections with the low-impedance crossover intact and in-circuit. This method, no doubt, does work. However, it neatly defeats the prime object: both amplifiers still handle the full frequency spectrum, and only at their outputs are they 'told' (in human terms, and tube-amplifiers are very human) that part of their load or effort was carried wastefully and will not be required in the scheme of things.

Far better is Bi-Amping in the true sense, wherein the amplifiers are 'told' in advance (at their inputs) to handle their own allocation of the frequency spectrum. This involves a high(er) impedance crossover of a sort: if it is to be a first-order 6 dB per octave filter (for that is what it is) then one can, with fairly sensitive amplifiers such as ours at approximately 800 millivolts into approximately 120 kΩ, achieve this with relatively simple passive components 'in-line' (or in series) with the input cable; some dexterous folk manage to fit these inside the RCA plug. This in effect means restricting the low-frequency information into the 'treble' amplifier and also gently tapering down the high-frequency information sent into the 'bass' amplifier. If one wishes to go further up the tree (there is always a "further" in blood-sports such as bull-fighting, motor-racing and audio) then one can consider a second-order filter of 12 dB per octave, a third-order one at 18 dB and even a fourth-order one at 24 dB. As always when one goes deeper, it gets more complicated, problems enter and multiply (sometimes becoming self-defeating, such as phase-shift and 'insertion-loss') requiring additional amplification. Logically, if one causes 18 or 24 dB of attenuation by filtering this amount, the loss will have to be made up again by another 'box', another beast, needing to be plugged in, called an 'active' (gain-producing) crossover or commonly just termed 'an electronic crossover'.

Often these not-inexpensive devices have doo-dat knobs on them to continuously alter (fiddle) with the turnover point/s: more knobs and decisions to interfere with the music. We feel strongly about a 24 dB electronic crossover (or anything else that was not absolutely essential) in the signal or music path. For this is a **VTL** code, dictum, principle of design-belief: simpler is better; less (circuitry, componentry) is more (music)...and we don't care who mocks us for adhering to this faith (the most knowledgeable people never do.) Delving briefly(?) into Tri-Amplification for a moment, let us just say that if this translates to you as having one amplifier for the 'treble', another for the 'mid', plus a third for the 'bass' then we are back to the "squawker-syndrome" as discussed in the section on LOUDSPEAKERS in this chapter.

We have a friend in Japan, by the way, who is 'into' *Quint*-Amplification: he has a super-tweeter (ribbon) triode amplifier, a tweeter (horn) triode amplifier, a mid (horn) triode amplifier, a lower-mid/upper bass tetrode amplifier and a low-bass pentode amplifier. Oh yes, this is a stereo system of course, and his amplifiers (also of course) are monoblocks. Then there is the matter of his (custom-built) 12 tube per channel 5-way crossover of 18 dB per octave. Would you think this was going a little too far? The gentleman in question is an avid audiophile (as distinct from audio-musicaphile); he plays sounds of steam-engines and the like, and is not thought of by his friends as being a totally well-oiled machine. Interestingly, Japan has about 50,000 so-called "Ultra-Fi" (we like that word) hobbyists, nearly half of which use tubes (we like that even better.)

The classic Bi-Amp is the two-way we started out with; this can be taken a little further with a Tri-Amp set-up where a true subwoofer becomes involved, but only to handle near-subsonic information with the crossover being around 40 to 70 Hz. Such sub-systems are mostly supplied with their own built-in amplifiers. We offer, as an optional extra, the possibility of a two-way 6 db per octave crossover being installed inside our **Ultimate** preamplifier with the turnover point pre-set (at the factory) of anywhere between 750 and 2500 Hz. It is not possible, in terms of space, to fit the 'sub' type of turn-over point (*i.e.*, below 100 Hz).

Please understand that we are not in any way trying to promote the complexity of bi- and tri-amping; some folks have speakers that lend themselves to it, together with room sizes that need more power. In those circumstances it is a technique worthy of consideration; no more, no less.

4

Cables and Interconnects

There is a definite art in selecting and interfacing audio equipment which would include setting up all the equipment in the chain between the actual recorded music and what started out as a silent room; all this connected together with flexible wire, cable, interlink, hose (call it what you will) and therein hangs a tale...

In bygone times (not that we're so sure they are truly bygone) some loudspeaker's package included about ten feet of flat or twisted lampcord. Possibly the manufacturer did not stretch to this sort of luxurious freebie and meant a trip to the electrical store to buy some: lampcord, zipcord, aerial wire, speaker wire — it was all the same anyway!

This was mainly the situation all through the tube and early solid-state period. (Mind you, there were many enthusiasts who 'knew the score' and the sonic value of good, heavy gauge wiring.) Somewhere along the time of the arrival of the so-called 'hi-fi' or early audiophile-quality solid-state equipment, some genius (he was and he is) thought "hold it a minute, we're dealing with higher current now — *there* is a market for better current-carrying loudspeaker cable..." The game was on!

It started with better-packaged battery-charger cable and has kept on developing to this day, to where the cable is almost assuming component rather than accessory status: there are types that cost *more* than some components! No doubt the good ones are really good; one or two engineers have made a specialised study of the science and truly closed the connection gap. After all, it must make sense to connect top-class equipment with decently conceived and engineered cable; a chain is only as strong as its weakest link, and all that. Mind you, we couldn't resist laughing when it happened or smiling as we remember it now to tell you: some of the early cable was *too* good, in terms of near-zero resistance and absolute current coupling, for some of the 'breakthrough' solid-state amplifiers, and they duly broke through. It seems that their design took into account and actually depended on that little bit of resistive and current loss (in zip-cord and the like) to 'lengthen' the path to the loudspeaker (which can present itself as a virtual short-circuit at low frequencies with high power).

You probably know by now that we at **VTL** go to considerable trouble and expense with the quality (and quantity) of the wire we incorporate internally in our units. Our layouts are studiedly compact and tight to shorten the signal path: what beats any wire is no wire; what beats the best wire is the shortest best wire. After extended and continuous listening evaluation, we chose to have special "Golden Section" (patented) multi-gauge Litzwire formulated for us by George Cardas of Cardas Audio, whose fine range of loudspeaker and interconnect cables we helped launch into the market and sincerely recommend.

George Cardas experimented for years with almost every conceivable combination of wire types and, when he hit upon his approximate final formulation, he realised that what he had in his hands finally was a natural ratio, commonly known as "golden proportions" among those who study and are interested in the Fibonacci numbers, a ratio that crops up again and again in nature. These numbers occur in naturally logical proportions of a rectangle, a triangle, the joint-distances on your fingers, a chambered Nautilus shell...The list, like the Miracle of Nature itself, is endless, and boundless. For the record, "Fibonacci" was the pen-name of "the other Leonardo", a scientist who came from Pisa and who pre-dates da Vinci by some three hundred years. Leonardo of Pisa was greatly fascinated by the recurring ratios of Nature and made a lifelong study of them, always publishing his findings under his pen-name.

Our "Leonardo" (a.k.a. George) gives an absorbing lecture on his wire, pointing out the value of immaculately tight binding in high-grade Teflon dielectric, superior screening by foil and braid which together with skilled and painstaking plug-terminations (absolutely air-tight) all combine to make his cable totally silent: neither allowing external 'crud' to get in, nor adding any noise of its own. He goes further into resonances and dissonances and more. Suffice it for these pages though, to assure you that his reasons and foundations notwithstanding, in simple terms, his wire delivers the goods.

There has recently been a resurgence of interest among the Press (mainly British) and the public in solid-core wire, and indeed there are one or two marketers of such wire whose products are, no doubt, well conceived and executed. Some respected, knowledgeable people sincerely believe in the merits of solid-core wire over stranded, not necessarily Litz-type, varieties. We certainly do not dispute their right to have this conviction. We use a certain amount of 'solid' in what we feel are the appropriate places inside our amplifiers; we well know and have heard premium-quality solid copper-wire producing some wonderful sound as loudspeaker cable, notably when driving Quad Electrostatics with our amplifiers. However, a) the wire needs to be of substantial gauge in our opinion (at least 12 overall) and b) it needs to be absolutely protected from oxidization arising from exposure to air/oxygen. T.A.R.A. Labs (Australian in origin) specialise in this field with their "Space and Time" series, and excellent cost-effective cables they are too.

When not protected (and we mean sealed as in a vacuum) copper will oxidize, will actually de-compose (become less in mass) and will diminish in sound-quality, adversely affected inter alia by its decaying skin-carrying propensities. Enter Litzwire, which is coated, every strand, in high temperature Urethane varnish to keep the copper oxygen-free forever; also, being multi-cluster and inherently more flexible, the 'end-problem' is lessened. It is a great deal harder to work with, to dress, 'tin' and solder, but well worth the bother.

One time we visited a dear friend (he must be regarded as 'dear' because we didn't even sue him when he attempted to make a 'Chinese copy' of our designs!) who has been a **VTL** fan from the very outset. He was using some strange cables indeed that day: as interconnects he had two strands of the finest (about 36 gauge) wire meticulously press-sealed between two pieces of sticky-tape (no air could enter) which, of course, also had no shielding. In the loudspeaker link he had very heavy solid-copper cables (about 12 gauge) going to his Quad ESLs. Moreover, he had them stapled to his wall (he has a charming, understanding wife!) so that the cables could not get damaged by movement. And it sounded good, really good. However, it turned out (as it often does) that the solid-core/sticky-tape interconnects merely sounded different, as distinct from better, and they were consigned to the trash-can. But the 'speaker wire stayed for a long while.

We must include some mention of bi-wiring, the use of separate cables for the tweeter and woofer in a two-way loudspeaker. Bi-wiring makes a startling improvement to a good loudspeaker, and recognising this, quite a few speaker manufacturers have offered their units "bi-wire ready" with separate sets of terminals. If your speaker does not have these and you wish to hear what bi-wiring would do for your life, please allow us to suggest that you take them to a dealer or technician for modification; a badly done (butchered, we call it) mod seriously hurts the resale value of anything, while a professionally modified item's value can actually be increased. Also, if you are not familiar with loudspeaker circuitry, you could wrongly connect the bi-wire *after* the cross-over, thereby causing the tweeter to 'see' the full amplifier output and totally burn out. The effect of bi-wiring is one of those things that the most erudite scientists cannot measure, though they concede (grudgingly, because they don't like things they can't measure!) that the improvement in imaging and staging, plus an added smoothness to the tweeters' domain, is very clearly audible. The scientific reasons for bi-wiring's benefits are not all that clear, but it has to do with the two driver units having a separate 'low' or ground lead (rather than a 'common') as well as the effect of 'back EMF' interaction from the woofers' motor to the tweeter. As they say: try it! You'll like it!

Back to solid-core just for a moment: we read in an audio magazine, just a week or two before this book went to the printer, a letter from a subscriber wherein he had "progressed"(!) from 18 gauge 'zip-cord' (commonly seven strands) to 24 gauge tinned-copper solid wire purchased from honourable Radio Shack. This he was using for loudspeaker cable from 225 watt amplifiers. Now we make a 225 watt unit, and we hope to Heaven that somebody else does too (*i.e.,* that he is not using **VTL** 225's). Regardless of who made the amplifiers, 24 gauge is just too damn thin (no argument) to carry that sort of current without loss [*see* "Resistance" in WIRE-GAUGE TABLE in the Appendices]. We wouldn't even use 24 gauge wire in preamplifiers! Looking at standardly available fixed resistors' leads gives a clue: a quarter-watter normally uses 26 gauge (again, we wouldn't dream of using that size) a half-watt uses 24 gauge, a one-watt uses 22 gauge, while five and ten watt resistors use 18 plus gauge.

At the end of the day, we defend everybody's right to prefer the sound of a certain cable over another in their system, whatever they find to be lastingly musically satisfying and whichever best suits their particular equipment and 'taste' interface: which is why is why we prefer a reviewer to *quantify* "best" by adding the words "...in *my* system."

Balanced and Symmetrical Wiring

The concept of 'balanced' wiring goes back to the beginnings of electrical recordings and is standardly employed in virtually all broadcast station and recording studio inter-wiring; especially where cable runs might be hundreds or thousands of feet, miles even, as exists between studio and transmitter buildings for instance. Most commonly this system uses 'line' transformers almost always with the shield-braid connected to earth *and* the centre-tap of the winding between the 'hot' twisted signal-carrying pair; this is the classically correct description of the 'balanced' technology. When the transformer-winding has no centre-tap, then the technique is more correctly termed as being 'symmetrical'.

The standard broadcast-balanced lines are usually of 600 ohms impedance. The main reasons for employing this technique are to reduce or eliminate high-frequency losses caused by cable capacity in higher-impedance interfaces and also to avoid hum and noise, RF and EMI interference. Even when *unshielded* the twisted-pair, *each of a different phase relationship,* (phase and anit-phase, plus and minus, start and finish, etc.) enjoys a phenomenon known as Common

Mode Rejection Ratio: a hum and noise-cancelling effect that is also found in the push-pull stages of an amplifier.

If one takes an inherently *unbalanced* (single-phase) signal and inserts a transformer or electronic phase split-invert circuitry into the signal path, we would term this as being *overtly* balanced; *i.e.*, adding otherwise unnecessary circuitry or componentry purely to take advantage of the Common Mode Rejection Ratio for the sole purpose of allowing a very long cable-distance of more than, say, thirty feet between preamp and amplifier.

For example, if the hypothetical preamp and amp were to be of the 'integrated' variety on one large chassis with total power-supply isolation, would one then build in all the additional phase-inversion and balanced circuitry to connect the two sections over a few inches or a foot? We think not; but then we are deeply committed to the "less circuitry is better circuitry" approach.

Let us examine the obvious-seeming for a moment. Broadly speaking, there are two popular modes of stereo-system interconnection: the "traditional" (born of tubes) and the "modern" (born of solid-state). The traditional installation has all the electronics and sources at one end of the room with *short* (two to five feet) interconnects and *long* (fifteen, twenty, or more feet) loudspeaker cables to the "speaker side" of the listening room. Just for the record, let us remember that this method is good engineering practice from the point of having the smallest voltage signals running on the shortest cabling. (Not to be ridiculous, but who would ever run, say, the cartidge output over twenty or thirty feet of wire to the preamp?!)

The "modern" way is the very opposite, having the preamplifier at the source-location, driving fairly long interconnects to the amplifiers placed near the speakers using very short (two to six foot) speaker cables. This is very akin to "studio-teknik" (600 ohm-input amplifiers *built into* the speaker cabinet) and is particularly well-suited to solid-state amplifiers delivering high current into the speakers. This is cost-effective and less intrusive to boot: some of the "speaker hose" is graduating from garden-hose to fire-hose proportions — and price!)

Incidentally, where cable-comparison reviews are concerned, they would be of greater value yet if the long/short norms were stated and rigidly observed reviewer-to-reviewer based, say, on six-foot speaker cables and 25-foot interconnects. (We feel that 25-foot interconnects should be considered as the sensible maximum length; if one were forced to go longer than this because of extreme room-size, it would be better in our view to add the extra feet to the speaker cables.)

Correctly installed, top-quality High End stereo equipment can easily outperform typical recording-studio chains by the very fact of shorter, better-quality unbalanced cable runs among other things. Nobody in the broadcast or studio arena would claim that the inclusion of 600 balancing devices *adds* to the sound quality, rest assured. Though mandatory for reasons of spurious-noise avoidance, the inclusion of extra devices *impairs* the sound path. Many is the time we have removed (by modification) input transformers and circuitry from studio tape machines and mixing consoles for great sonic benefits when the *shorter, hotter, direct cable run was possible.*

A well-proven adage goes "the better the (overall) circuit design, the less the need for 'balanced' circuitry." Or as we would say, "anything that *can* be left out is *better* left out." In all fairness, we should explain that when a circuit originates with a symmetrical device, it *is* possible to face this into a *differential input circuit* (split-phase) and keep the circuit differential *all* the way through and *past* the output devices right up to and including the loudspeakers (or cutter-head, tape head, digital bean-counter, whatever). This is very costly technology though, almost doubling compnent count, space, etc., and making even selector switches and volume controls into complex, highly expensive devices. If deemed a truly worthwhile benefit, we'll bring it out in all-tube circuitry before anybody else does, of this you can be assured.

On the dual-notes of 'before anyone else' and 'inherently symmetrical', let us tell of our most recent breakthrough: that of connecting the only inherently symmetrical component in the whole chain — the moving coil cartridge — into a specially conceived symmetrical input, called by us *floating symmetrical mode.*

Floating Symmetrical Mode

This was first nutted out by us about 25 years ago(!), and we have been tinkering with it on and off ever since, wondering when or if to publicly release it. The first purpose was for a dynamic (moving-coil) microphone wereby it was desirable to go straight from the coil into the symmetrical circuit, excluding the preamp and mixers' input transformer *and* the 'output' transformer built into the mike itself. The results were excellent.

Then we wondered about its possible value to the moving coil cartridge. There were not too many around at the time; Leak and Ortofon cartridges with *de rigeur* input transformers. We had the benefit of doing experimentation right on the lathe's turntable, where the Ortofon cutterhead (also 'floating') was driven by our own custom amplifier fed from superb master-tapes. One could listen to the 'symmetrical' replay circuitry without even lifting the lacquer from the lathe!

We were seeking to unlock *all* the sum-and-difference information on Blumlein-style (and approved variant) recordings, the ambient and dimensional detail present on the master tape and faithfully etched into the lacquer by the cutterhead: what EMI called "StereoSonic" information in their proprietary professional recording equipment (never publicly marketed) which utilised Alan Blumlein's clever thinking on phase relationship, sum and difference. We own one of these mixers with his passive "shuffler" circuitry plus a number of historic working-papers.

Having proved that the interface and circuitry achieved this, but not having a 'brand' of electronics at the time, we were worried as to the wisdom of trying to release it to the so-called audiophile market. It was offered to one or two other manufacturers, who deemed it "too radical; complicated; not in step with standard arm/turntable wiring," with the consolation, "perhaps later."

Well, "later" is now and in vynyl's seemingly twilight years, it is clear that the folks who play their music from vynyl have serious turntable/arm/cartridge setups easily able to take the symmetrical connection, plus the taste and knowledge of the vast gap between analogue and digital, between music and just sound. We previewed a somewhat de-tuned version at the Las Vegas CES in January 1989. The reaction from trusted friends was that we were "onto something" indeed.

Floating Symmetrical Mode is a totally symmetrical input (not connected to fround or 0 Volts at either end of the coil) with both the 'phase' and 'anti-phase' input ports' sensitivity being precisely matched. Common-mode rejection (of unwanted noise, hum, RF) is only a by-product benefit, as is the higher output-gain ratio of the cartridge/input circuitry. The real benefits are in the imaging, stage depth and width, allowing more perspective in the lower frequencies. The effect of 'lying flat' on the speakers is lessened; even surface noise seems to be pushed out-of-stage somewhat. Another known (and calculatedly expected) benefit relates to 'tracing distortion' [as distinct from 'tracking distortion' — 1812 cannon shots!] which cancels nicely. In the Floating Symmetrical Mode, the cartridge "sees" 1500 ohms, and this seems to suit every cartridge listened to in this mode.

There is one complication in the connection interface: the leads in the arm need to be two twisted pairs (common enough) and they have to be brought out in a 3-pin connector. We have opted for the XLR type, the best available. These connectors are easily obtainable, even with gold contacts, at places like Radio Shack. We are supplying a 58-inch Cardas cable with each preamp (available only in our **Manley Reference** and **VTL Ultimate** units). One version of the cable goes from the turntables RCA outputs and another goes from the arm's DIN plug (for the SME, Sumiko, etc.)

We're also working on a symmetrical approach to the lowly-seeming moving-magnet cartridge, made even easier because of the inherently high output (2 to 5 millivolts). However, MM cartridges sometimes have one of their "low" terminals (blue or green) strapped to ground or the cartridge body as extra shielding. Too, most of the less-expensive arms normally associated with MM cartridges are wired with coaxial cable (a braid plus a single "inner" core): this precludes symmetrical wiring.

We have also contemplated releasing the circuitry in a separate Floating Symmetrical Mode pre-preamp, attachable to anybody's existing favourite preamp. However, we dislike an extra "bunch of little boxes" and additional cabling. Yet if the demand is there, we'll meet it.

Finally, we will offer the proprietary technology to other manufacturers if they're interested, for a negotiated annual license fee. These proceeds will be placed in The Absolute Sound's Recording Fund to further benefit recorded music.

Custom or Special-Purpose Designs

In spite of our very extensive range of available production models (including the **Manley** product range) of amplifiers, preamplifiers and a CD player, it happens that individual clients require something not in our (or anybody's) catalogue. Examples of this are tubed electronic crossovers, custom-made for a particular amplifier/speaker combination; tubed tape-head preamplifiers with peculiar or multiple EQ curves (CCIR, NARTB, NAB, etc.); microphone preamplifiers and equaliser/'curve benders' or specialised end-requirements.

This latter category normally falls into the industrial recording-studio domain and not the so-called audiophile sector. This service, though, *is* open for Audiophiles who wish to commission 'one-off specials'. Examples are amplifiers designed around favourite output tubes, preamplifiers with two or three phono inputs plus, of course, customized cosmetics — copper, brass, bronze, even gold-plated metal-work perhaps combined with exotic woods: your imagination is the only limitation. However, be advised that this sort of individual 'art work' is not inexpensive! The one-off metal-fabrication charges are ofted costed at 50 and 60 dollars an hour; non-standard plating finishes (where one may have to 'sponsor' the whole chemical bath for one or two pieces) are even costlier.

Another service we offer (and much enjoy) is the upgrading and/or restoration of *truly valuable* and *rare* classics, such as the Marantz 'Nine' or Studer tape recorders and tubed capacitor microphones of 'Royal' blood-line like Neumann, AKG, Telefunken and Hiller. The 'entry-passes' in this category are that the proposed equipment be in original, unbutchered condition *and* that the equipment has current value or irreplaceability far in excess of its original market-price. No offense at all, but this condition excludes more plentifully available equipment like Dynaco for the reason that we can provide *new* **VTL** equipment often at a lower price than the bench time needed to upgrade or rebuild the legendary Dyna Stereo 70. Also, the major components such as output transformers used in these cost-effective units are really not in our league of performance.

For the record, we happen to believe that the Dyna and PAS series of tube equipment was one of the most important events in the audiophile annals, bringing really good reproduction into average homes at accessible prices. Unconfirmed rumour has it that some 200,000 of these Dyna's were built, and we're happy to know that. From our own 'contribution to posterity' standpoint, we hope our "under a grand" (US mail-order selling price) stereo amplifier (introduced in June of 1989) will also reach a large number of 'un-tubed' homes that were previously excluded because of price.

Overseas/Foreign Importers and Distributors

We realise that not all of the world's markets have the same tastes or market needs. If you have developed a market base especially suited to a given area, please tell us about it; tell us about your particular requirements. If your market requires a special model or version of a model, we can surely produce it provided there is sufficient potential for the product. Many examples of this exist in our history; we supplied very high-quality, but modestly powered 25 Watt monoblocks to a distributor in Germany, special triode models and larger-chassis 'specials' to France, and currently a specially chosen 'mini-range' of models to America's premium "audio consultancy by 'phone" mail-order house, Messrs. Audio Advisor, Incorporated. They required a monoblock more powerful than 50 or 65 Watts, but less costly than our **Compact 100's.** We designed an 80 Watt unit especially for them which is also available to our export clients. Other models will follow, so even if a particular type you have in mind is not shown in our catalogue, *do* ask us: we might have it already in production or be able to put it into production especially for your market.

Dealers in Audio Equipment

We deeply believe in the importance of the specialised audio dealer in the scheme of things: demand, supply, advice, installation culminating in user satisfaction of the highest musical integrity... but Oh! is this a thorny topic for us *and* the audiophile we ultimately wish to serve.

The fact is that outstandingly professional audio dealers are outnumbered (many to one) by mediocre (alright then, let's say it, downright poor) dealers the world over. The problem is not confined to smaller market places; on the contrary, it seems manifest especially in the larger market places where the buying populace is large enough to hide the Michael Mouse calibre of the dealer.

By the very nature of **VTL** being a somewhat specialised product, the terrain is thinned out even more. And yes, we understand that the acquisition of the required knowledge, experience *and* the financial resources to set up a true High End store don't come easily, but we take the "do it properly or don't do it at all" point of view.

So many problems face the new or intending audio dealer: what lines to carry (often limited in availability by existing competitive stores), what lines to demonstrate (not easy with, say, cartridges) plus, of course, the fact that from the available lines, the dealer must select combinations that interface and complement each other.

The audio magazines make well-intentioned suggestions like "audition this cartridge at a dealer *before* you buy." Indeed, the would-be customer may well wish to do this: but *where*??? Worse yet, what if they does not live in a metropolitan city? Should they jump on a plane to New York? (This is actually not the worst idea if one were contemplating a "windfall" total system — it could easily be worth the time and money to take a trip to a city where almost everything on the shopping list is available on demonstration.)

Next comes the human aspect of customers' personal likes and dislikes (we do not decry their right to have them!) that sometimes cause them to audition a ton of equipment at one or another dealer and then *buy* it from yet another. Understandably, this drives dealers to dementia. It filters on through to manufacturers like us, too; we just cannot understand why a customer will walk out of a store that has "got it in stock" and into a store that does not! Would you purchase a car from a dealer who had only one — or *none* on his floor/lot? Well believe us, this happens very often in audio, which brings us to the distinction between 'dealers' and 'brokers'.

A stock broker does not keep the shares you want in his safe; he gets them for you at your specific reqest. But a dealer is supposed to be one who has investigated a product or line, believe in it, and shows this by investing in and stocking it, demonstrating it to you and, when you give the nod, offers to put it in your trunk or, better, to deliver and install it in your home... and then be ready with willing after-sales service if needed. You think this is a fairy-tale? No; it happens daily at properly run audio dealers, but sadly these are not over-abundant.

We at **VTL** have had to be very selective about appointing dealers, preferring those who had a full understanding of tube products *with* a resident technician and a workshop. This makes our dealer list very small, indeed. However, we'd rather miss the business than have the item wrongly, unhappily sold to a dissatisfied client.

So what is the message here for the buying audiophile? Select the dealer from whom you wish to purchase with some pre-planned care. Ask, by phone in advance, for an appointment and find out whether they will have the gear you wish to hear ready and plugged together. Don't expect to arrive to hear Inifinity Betas and then ask the dealer casually to whip up some Magnepan Tympanis! A good dealer would require advance notice to set up the demonstration carefully. Remember, if the demo is shoddy, you won't be impressed and won't buy; your time and the dealer's is wasted.

What to do if you have no specialized dealer near you, and you're seeking an amplifier (rather than an entire system), say? In the first edition of this little book, we pondered whether telephoned mail-order was ideal for audio componentry; we recommended that a walk-in dealer with a demonstration facility was better. We still feel this way *if* one has the choice. In the absence of such a facility, we realise that long distance ordering may be the only option. In this instance, again, choose with care; choose the firm that is prepared to spend time with you on the phone, that takes the trouble to hear about you and your system as if you were in the store itself, that offers a technical facility if you should need it later. After all, if one were interested in high performance sports cars, there is not a Lamborghini or Maserati dealer in every town! And if one wanted to order a 'hot' carburetter for such a car, you'd just *have* to get it in the phone directory, wouldn't you?

Tweeks

Eeeek! A Tweek! (This is a cry for protection against these congenitally fiddlesome human souls, and not a denigration of a fine product of the same name which, however, can be and mostly is, used to excess with dangerous results by the tweeker-brigade.)

Knowledgeable, trained people who modify equipment to suit a special purpose or to effect a major improvement cost-effectively are not what we are discussing here. No; tweekers are folk who are unhampered by knowledge, unsullied by experience and unapologetic after ruining a fine piece of equipment in the practise of their (self-discovered) talent. They are, in a word, a disaster.

Some of their expertise is typified by the following list of 'improvements' that we, or some other suffering trained engineer, have to un-improve and restore to working condition: The *drenching* of tube-bases (which carry high voltages) or any other separable contacts in "Tweek" or other other contact-enhancer. (If it can enhance a contact it does, by definition, conduct electricity, no?) The fitting of heavy-duty sorbothane (or other wonder-substance) condoms around the circumference of respectable tubes impairs the tube's natural flow of heat convection, causing it to get hotter; the ring can melt, leaving an awful mess in the chassis or board and/or cause tube-failure from excess heat.

The constant plugging-and-unplugging sequence of tubes or any other removable socket that these neurotics think is essential to perform on a daily basis; often accompanied by the scraping of contacts with sand-paper or tweekers' scalpels — the better to pile in more "Tweek". This loosens the socket's tension, often to the point where the tube slides in and out with the force of gravity alone: no tweeker has ever heard of re-tensioning sockets, much less how to go about it.

The tightening of binding-posts with plumbers' pipe-wrenches or mechanics' torque spanners. "Gotta get these suckers (puff) *real* tight y'know. . .ya'd be amazed (puff) at how much sound escapes..." (Yeah: and how much expensive plating the wrench strips off; also how the wires break off inside because the whole terminal has been windmilled.) The bridging or replacing of fuses with heavy wire: "Just one itty-bitty fraction of this garbage fuse-wire, man, totally wrecks the imaging, man." What it really wrecks is the equipment, if something should go wrong. What it can also wreck, by fire, is the whole house.

The replacing (or rather displacing) of tubes with others that happen to have similar sizes or number of pins is another deplorable practise. "I read someplace that these types sound bad, like I mean *real* bad; lets roll in these babies that I got in a very private-bar." The tweeker wouldn't know a tube-manual from "Pravda" — or even that such things exist. He doesn't dream that certain tubes, a 7027A for example, have an internal strap-link that would cause a 100 percent high-voltage short when plugged into the socket of, say, a 6550.

The installation of little two-tube adapters, sometimes known as "T-bars", so that two halves of separate twin-triodes are combined to use two tubes instead of one for "better, er, everything". Yes, and what about little details of stray capacitance and hum pick-up?

The indiscriminate replacing of capacitors with other 'hot' numbers: "These caps you got in here, boy, are bad news. Lets solder in some of my special babies. Whadya mean, working-voltage? Batteries have volts; caps have, er, microdots!" Capacitors do have voltage-ratings and, often, polarity; the designer put certain parts in for not-always obvious reasons.

The soldering-in of 2, 3, or 4 ohm fixed series resistors into amplifiers and/or loudspeakers with the intention of altering the impedance-match, after measuring the DC resistance of the transformer secondary or speaker voice-coil with a multimeter! This would have a disastrous effect on the power output; the DC resistance of our output termination is on the order of point one ohms, which bears no relationship to its actual impedance.

The list is endless. One thing tweekers do really proficiently is the voiding of manufacturers' warrantees. *Be warned.*

5

Preamplifiers In General

Make no mistake, a good preamplifier is hard to build, and much, much harder to design. This is mainly due to the fact that one is dealing with miniscule signal voltages hindered by the 40 dB loss of the RIAA curve. Furthermore, the preamplifier is required to be "all things to all men" in the sense that it is expected to have sufficient gain to amplify almost nothing up to and beyond line-level without adding noise, distortion or its own sonic signature. And having met those demands, the next person requires that the *same* preamplifier accept a moving-magnet cartridge with perhaps fifty times the output voltage and still not overload the little point one millivolt input ["and why is the volume control not pointing to 'midnight', you incompetent dolt???"] Some tough assignment, we think you'll agree. It's made somewhat tougher yet by the fact that the preamplifier has another role to fill, which is that of a central routing switchboard. In fact, some of the older literature calls them "control centres". In essence, it cannot be done. Or rather, the examples available from people who think they've done it do not impress us.

The only way, as we see it and do it, is to divide the problem into a pre-preamp for the MC followed by a phono and line preamplifier. (In the same cabinet, we mean, because surely nobody really *wants* another couple of little boxes plus more interconnects to pick up more noise with more losses on additional plugs/sockets plus the extra mains cord to induce more hum to these and the original MC cable?) And, yes, you can use an MC step-up transformer, but they are very susceptible to EMI (electro-magnetic-interference) and the reviewers we respect don't seem to like their sound either.

Our preamps all have the moving-coil stage built in (excluding the **Maximal**) and, considering that they're all-tube units, the noise-level of the MC stage is very acceptable. (Funny, we always think, that here is one place where the transistor should be in its element: a low-impedance 'coil, say around 100/200 ohms?

An ideal match for the little beastie...low noise-level requirement? Just what the doctor ordered (only he was a deaf doctor, remember).

Yet another duty that some folk expect of a preamplifier is that of "dubbing-console switcher", and here we draw the line: so sorry; we honourably refuse to oblige. May we tell you why, please? Primarily it concerns contact resistance or loss factors, affecting the higher frequencies; and remember, we're talking pre-amplifier language here with the signal in its smallest (and therefore most fragile) state. Let's count the number of 'pressure' or touch-contacts that could in a worst case arise in the chain *before* the amplifier:

1) Cartridge to clips in arm-shell
2) Head-shell to arm (Horrors!)
3) Under-arm DIN-plug
4) RCA-females on turntable-back
5) RCA into phono input
6) Input selector-switch
7) Output selector-switch (recording)
8) Tape-loop switch, monitor
9) Balance-control wiper
10) Volume-control wiper
11) Bass-control wiper
12) Treble-control wiper
13) Filter or doo-dat switch
14) Preamplifier output RCA's
15) Amplifier input RCA's

Phew! Poor little signal! We obviously, as do High End manufacturers, leave out the totally unnecessary tone-controls; but we leave out more still in senseless-switching, and in our design of balance-control. Have you any idea of the losses caused by the above chain? We have both listened and measurement-quantified them to commence onslaught at 8 kHz. (Gadzooks! This is thirty-buck portable-radio territory!). True: this is half a dB down at 8 kHz, one dB at 12 kHz, one and three-quarters at 16 kHz, three at 20 kHz...

Now, if you want to add ten or twelve inches of PCB track to make some of these switches look a little neater in assembly (and neater still in balance-sheets), why, just deduct some more upper-frequency dBs. By using Rhodium connectors, good wire and solder, omitting 'toys' plus eschewing signal-on-tracks, we are able to go 'flat' to 100 kHz and above. Our preamplifiers are designed with the *first* playback foremost in mind; we are not prepared to compromise this standard of our critical design criteria to the level of a lo-fi mass-produced (by the mafia of mediocrity) cassette deck. Tapes for your car? Well, if you must, you must.

Which is why our preamps *do* have an excellent record-feed output — some of them are even buffered to reduce the risk of contamination.

What they *don't* have is a multi-deck rotary switch marked "Input deck # 1, 2, 3" etc., routing to outputs '3' and '2' but not '1', etc. Also, they don't have (never had, never will) the switch marked "source/monitor" (sometimes called a "tape-loop" switch). This is exactly the doo-dat which forces the critical listener, who may have no desire whatsoever to re-record a record, to accept a sound degraded by the signal cables being brought all the way to the front panel via an extra switch so that a less discerning listener can make copies. Interestingly, switching over to "monitor", which is to the playback or third head, only ascertains that: a) sufficient finger-pressure was exerted on the RECORD button; b) the ruined-looking tape left on the dashboard sounds even more ruined than it looks; and c) Stone me! Overmodulating much into the red *does* cause distortion, like the instructions said.

Besides, standard operating procedure in the professional recording game advises that one should use good tape of known quality, avoiding the need to monitor on "third head", because the possibility of a tiny leak in the change-over switch (even 50 dB down) from the playback head to the record-head circuitry will print a very faint echo-effect, thereby marring the recording anyway. (Please ignore this last paragraph if your tape-recorder happens to be a tubed Studer, EMI BTR2 or Telefunken M10).

Cartridges, Loading and RIAA equalization

Proper attention to cartridge-loading is one of the most worthwhile improvements that can be made to a system, especially with regard to moving-magnet cartridges. No, don't write them off: a good MM correctly mounted in a compatible arm can produce wonderful music when facing into the optimum load in resistance and capacitance. The MM cartridge manufacturers know this, and their recommended-load suggestions should be followed at least as a starting point. The superb Decca (as modified by the Garrott Brothers of Australia) can easily take an 8 kΩ to 12 kΩ load to optimise it. Loads for MC cartridges, however, seem to be a very contentious matter.

One school of thought says that the MC, any MC, should and must perform properly into a standard 47 kΩ load. There is support for this from studio-microphone experience: most microphones (and a dynamic moving-coil mic is very akin to a moving-coil cartridge) perform best when looking into a load of ten to twenty times their nominal impedance (if you can spare the gain). Another school says that a 100 ohm cartridge should "see" a 100 ohm load. The third school says it all depends on the individual cartridge specimen, its number of hours run, and how it sounds with various loads. We take that viewpoint, and therefore offer many switchable options in our preamplifiers (except in the **Ultimate** and **Manley** units with Floating Symmetrical Mode; with the reduced 'tracing' distortion offered by FSM, an optimum average load is fitted).

A cartridge, like a loud speaker, is a motor of an electro-magnetic nature and, to some extent, the load serves as its gearbox, clutch and brakes, affecting its "speed" as well as optimising its linearity and distortion characteristics. Since the designer of the preamplifier endeavours to keep deviations in the RIAA equalization to under one quarter of one decibel, it is only fitting that effort should be made to see that the cartridge itself is optimally loaded to maintain its accuracy.

And what about the RIAA (Record Industry Association of America) curve? Ahh, the RIAA curve...we'll tell you a little about it if you promise faithfully not to abandon records completely in these troubled times. Well, the actual master-disc from which the record is eventually pressed (we'll leave out the sordid details of mother-matrix-stamper) cannot in fact accept the full frequency spectrum at equal levels of amplitude. So, for two major reasons, the curve has to be altered very drastically to accommodate this problem. (You *promised*!)

If one attempted to cut a microgroove LP with the full frequency range absolutely 'flat', or unequalised, (as we have indeed done many times for test-purposes, at 78 rpm on grave-silent lacquer with a groove-pitch of 80 lines-per-inch — which yields all of 2 minutes on a 12-inch side) two horrible phenomena would occur: one, all the lower frequency sounds would cut literally over and into each other's groove (and you thought you had mistrack problems, buddy?) and two, you'd find that you could not hear much of the upper frequencies clearly either, because of the rushing-faucet sounds produced by the playback stylus' friction in the grooves, locked or otherwise. Whence cometh the need to attenuate (reduce) the bass frequencies under 1000 cycles (Hz) and boost (increase) the treble frequencies above the same turnover point in the master-cutting process. Then when you play the final record back, you have to reverse (in the preamplifier) the order of events by lifting the bass and also by cutting the treble and, by courtesy of the latter effort, the surface noise goes down with it.

One of the not-so-elegant by-products of the scheme is that in lifting the bass in playback, you also accentuate any mechanical vagaries of the turntable in the form of rumble. This is why a really good High End turntable needs to be built at or near the same standard of quality as the mastering-lathe — and costs accordingly. The amount of cut-and-lift of the RIAA curve is 19.6 dB. Praise be that the world at least saw the sense of adopting it as a standard; before that one had "Columbia LP", "British LP", "NARTBLP" and others [*see* Appendices: RIAA Table]. Also included is an easily constructed *inverse* RIAA network of resistors and capacitors; this is a very useful little test item used for checking the accuracy of a preamplifier's RIAA curve.

We come now to the the actual circuit design we use for reversing the RIAA recording curve in the **VTL** preamplifiers, and why we choose this type of circuitry [see relevant schematics in the Appendices]. We accomplish the RIAA EQ with active techniques — the use of frequency-selective negative feedback. We have listened, measured, and listened while measuring exhaustively to our circuitry, and remain convinced that this system is musically far superior to the alternative of passive circuitry (resistor and capacitor networks which cause an insertion-loss of 40 dB to the circuit). We have found passive correction networks to be grainy, slow and lifeless: and disproportionately sensitive to type and design of capacitors used in circuit. Moreover, the elegance with which the RIAA curve is reversed in an active circuit is almost breathtaking.

Consider: you need to lift the bass by 20 dB at the lowest frequency — so you simply have 20 dB *less* feedback at the lowest frequency and appropriately less for the other intermediate frequencies (also thereby minimizing phase-shift to boot). Now you need to cut the treble, so with active cicuitry you apply feedback (which is gain-reducing) most strongly down to the frequency you wish to attenuate most, in this case 20 kHz, and proportionally less on down to the turnover point of 1000 cycles (1 kHz). And just look, while you were having maximum feedback at the highest frequencies, you were simultaneously reducing the tube rush, or hiss! Just like the surface noise mentioned in the recording process. Elegant.

Let us now examine the passive method: first you need to amplify the information from the cartridge with its excessive treble and dramatically reduced bass by at least 20 dB (because you're going to have to lift the bass by that much) and then you need to amplify it another 20 dB to make up the insertion-loss of the filter circuit needed to cut the treble by that much. . .and then you are still going to be without the gain-equalising effect offered by the feedback that arises from minute discrepancies inherent in each individual tube (or transistor) stage. (It is not technically feasible to have feedback over two or three stages if that chain includes a volume control or other filter network between stages.)

Preservation of Phase Integrity

There are a great many folk who aver they can hear 'Absolute Phase': they can clearly hear a difference when the phase (at the speaker terminals, say) is flipped: provided, of course, that the recording itself is 'clean' and fully phase-correct, there is no doubt that one way will sound more natural than the other. We call this the 'preferred phase'. This phenomenon was researched by a gentleman named Wood, and our friend Clark Johnsen has written an interesting book entitled *The Wood Effect*.

The problem of phase-inversion is rife in the recording process, and very hard to control! Every time a transformer or an odd number (one, three, etc.) of amplifying devices enter the chain, the phase is inverted. The reason is supposed to be that designers of all equipment (recording and playback) had a Golden Rule that everybody would strictly adhere to (*we do*): "Thou shalt not invert the phase."

Notwithstanding history and geography, we play the recordings that contain the music we like, right? And many of them are out-of-phase *within* themselves, more commonly with 'pop' multi-track material: baked and burned music, we call it! With this type of music, neither phase-flip will be more correct [see also the section on FLOATING SYMMETRICAL MODE].

One of the benefits of our recent breakthrough (we sincerely believe it *is* a genuine breakthrough) cartridge-connection and two-phase circuitry is the massive restoration of phase coherency, manifested in clearer acoustic dimension and location of lower frequency instruments. It seems "kinder" to muddled-phase recordings, too. We find this easy to understand when compared to the standardly-practised mode of cartridge connection with one side connected to ground or 0 Volts. We now see this common practice in near-human terms of trying to perform with one leg *nailed* to the ground. When one has two excellent recordings, both acousically recorded with simplistic phase-correct technique but each of *different* phase, this difference is even more palpable; but *both* sound marvellous!

There are only two *good* ways to flip phase: at the cartridge wires or at the amplifier/speaker terminals. Circuit manoevers of an *un*-balanced nature, where one 'cuts' a stage to create an 'invert' position are therefore not, by definition, exactly identical in both modes. Most folk (ourselves included) are not too keen on fitting a FLIP switch at the cartridge connection because of the miniscule voltage, contact integrity, etc. However, we *will* fit such a switch by request for a nominal charge to our **Manley Reference** and **Ultimate** preamps which feature Floating Symmetrical Mode.

The other good way to flip phase, at the speaker/amplifier terminals, has the *opposite* problem of a large amount of volts and amperes. Enthusiasts are rightly very keen on maintaining contact integrity there, too. We have, on many occasions (mainly for comparative tests) run speakers through very heavy-duty switches or relays using 100 Amp contacts with *absolutely no audible loss.* After all, there are not a few speakers whose midranges and/or tweeters go through pooky little 5 Amp — or less — fuse-wire for protection!

We have often wondered whether, properly conceived and executed, a remote-controlled loudspeaker 'phase-flipper' would gain any support in the market place. It would not be an inexpensive item to build well, but what an extremely useful facility it would provide.

6

Tube Power Amplifiers — A General Overview

VTL amplifiers, like all current tube power amplifiers, are loosely described as 'resistance-coupled' amplifiers — the distinction meaning that the amplifier contains no 'inter-stage' (or coupling between tubes) step-up and/or impedance-converting transformers, as did some of the very early examples of high quality amplifiers. The main reasons for the very old equipment relying on step-up transformers within the circuit were the unavailability of sufficiently high-gain input triodes as well as the fact that they were often driving triodes in the output stage: inefficient and notoriously hard to drive, requiring huge drive-signal voltages. D.T.N. Williamson, the famous British tube-designer, demonstrated with his equally-famous 'Williamson' amplifier in 1947 that a resistance-coupled amplifier using the more efficient tetrode (but triode-connected) could easily outperform the older design concepts, and the truly high-fidelity amplifier was born. The circuit topology of the Williamson had really only three main features worth mentioning here: a) an unusual and new method of balancing the output grids and cathodes used in "self-bias" mode, b) a tasteful and essential amount of negative feedback and c) a brilliantly-conceived and executed output-transformer, without which one had a very good, but not outstanding, amplifier of modest output — 15 to 18 watts. **VTL** amplifiers pay the same kind of heed to transformer design and execution that Mr. Williamson believed in (please see TRANSFORMER section) but our circuitry and other design concepts bear no other relation to his work.

Let us describe a typical **VTL** amplifier's general topology, starting with the all-important power-supply/s, for it is a fact that an amplifier (tube or solid-state) can only be as good as its power-supply (since the amplifier, after all, modulates its power-supply). We use diode rectifiers in a full-wave bridge configuration because they are totally reliable when built with the best components. We go to the trouble and expense of importing, from Germany, the Siemens type BY255's or BY229's for our larger models because these are the the only types specifically designed for our application. We have *never* had *one* break down yet; besides their inherent reliability, they're grossly over-capable with their rating of 1500 peak-inverse-volts (VrrM) and a current-handling capability of 2.5 amperes. A 1000 volt diode able to handle 1 ampere suffices in models of 100 Watts and under.

The second reason for choosing diodes is because our design calls for a very "stiff" supply, meaning inordinately high capacity at a very low impedance. The alternative to diode rectifiers is, as you knew or guessed, (a reverent pause, please) the vacuum-tube rectifier. *But,* and it's a big but, tube rectifiers were never contemplated to push capacity banks much over say, 100 microfarads, whereas we require ten or even twenty times this capacity. Even when driving up to 100 microfarads or thereabouts, tube rectifiers were and are notoriously unreliable, really having been designed for 4 to 32 microfarads. It would be true to say that the older tube equipment (radios, TV sets, amplifiers) usually pooped out because of power-supply problems: the "cap" started to die and slowly murdered the rectifier; the rectifier collapsed (by a short) suddenly and took the cap with it or variations on this theme. Mark you, the tube-type rectifier had one superb attribute: the rectified DC voltage increases gently to full value as the tube warms up, but one can live without that *if* one has the right bridge and computer-grade capacitors. We do.

The benefits of a "stiff, fat" capacity bank in our amplifiers' power-supply are palpably obvious when you first hear a **VTL** unit: the bass and low-bass is at once clearly deep and powerful, fast and 'tight' — attributes that are wrongly believed to be the exclusive domain of the solid-state amplifier. The following formula shows the relationship between capacitance and voltage in determining *audible energy:*

$$E = C \times \frac{V^2}{2} \text{ Joules:}$$

VTL amplifiers (300's, 120's, 225's and 500's) operate with 1650 mFarad at 550 volts, which is equal to

$$0;00165 \times \frac{550^2}{2} = 250 \text{ Joules:}$$

A typical solid-state amplifier operates with 10,000 mF at 50 volts (12.5 Joules); for a higher-priced amplifier, the specs might be 20,000 mF at 60 volts (36 Joules). This is the reason why our tube amplifiers sound "louder" than their solid-state counterparts — one can really hear the effect of the high volts and high "instant" energy. The output transformer has a great deal to do with this too, but no output circuitry can perform properly without this type of energy storage in the power-supply. It is possible, but very costly in terms of space, weight, heat and actual money to have a fully-regulated "B" or high-voltage rail operating at 500 or 600 volts at one half to two amperes of DC as it would need to.

Using the size, type and capacity that we do (typically 1700 microfarads rated at 700 to 800 volts-capable at eight or ten amperes of ripple current) we derive almost the same benefits as we would from full-regulation circuitry in terms of peak, instantaneous voltage, plus the low-frequency benefits that would not come from regulation by itself. It is the main power supply strongly aided and abetted by the independent supply for the input tube that gives our amplifiers their impressive slew-rate and hair-trigger rise times which reflect not only in the low-frequencies, but right across the full power bandwidth. This also enables the amplifier to handle transients well and to keep down the intermodulation distortion. (Intermodulation is described by, say, a strong pattern of string bass accompanying a solo flute many octaves apart.)

We might mention here that our filter capacitors are built to our order and specification to what is known as "Special Test Requirement." They are tested at ten percent over their marked working voltage at 10 amps of ripple current at 95° Centigrade simultaneously in an oven. When they come to us, we "form" them first, slowly building up their voltage to accustom them to their brave new world by 'pushing' them for a short period to 15 percent over their limit to ensure that they understand our demands.

Going on from the main high or "B" rail (and leaving out the DC heater and bias supplies which we feel are self-explanatory from the circuits) we come now to the separate and regulated "B" rail for the input tube as found in all our **deLUXE** monoblocks: we'd like to explain this only to the extent that we believe the input-circuitry should be treated like a preamplifier in terms of its voltage-rails, since it is handling signal voltages of close-to-preamplifier proportions. Furthermore, we like that input tube to "see" its operating voltage clear and clean, and in no way related or dependent upon the "B" rail used for the driver and output sections: this is called "purism", and it is where we want to be.

The input-stage in all models is a pair of Class A triodes (both sections of a 12AT7) connected in parallel. This configuration performs some interesting duties: it increases the gain by doubling the transconductance, thereby lowering the noise and impedance, and offers double the "headroom" (overload potential) of a single tube. Neat. The 12AT7 is an extraordinary tube in itself, having almost the amplification factor (80) of a 12AX7 (100) but yet having an anode or plate dissipation of two and a half watts; it could drive a small loudspeaker to quite a respectable output!

Now on to our driver/combined phase-splitter stage: it is necessary to divide the signal into opposing phase-halves for all push-pull output stages, and the driver tube does this while adding some more amplification to feed the output tubes' grids. Here again we chose the hairy-chested 12AT7 or its even harier-chested big brother, the 12BH7, and configured it in a combined "long-tailed pair/floating paraphase" circuit. In the **Manley** series, we add yet another dedicated power supply for the driver stage/s, to also keep it spearate from the output stage's supply. As with our input circuitry, every possible variation was constructed, measured and listened-to extensively in real music terms, both in playback and recording. The ones we chose to go with won hands down.

A few words on our fairly high input-sensitivity are worthy of mention here: this is on the order of 0 dB or 775 millivolts; we have explained more about this elsewhere. The main reason for choosing this is that by requiring less output from the preamplifier, the preamplifier itself gains more head-room (and yes, also noise; so the preamp needs to be up to the job). Another reason was that we like our amplifiers to be at "studio standard" so that they can be (and are) used as monitor amplifiers. The third reason was not pre-planned but arose out of the last-mentioned studio aspect: most tape-recorders and CD players can drive our amplifiers to full output — and we do mean *full* output — which is why we fit volume-controls to our stereo amplifiers if so required.

We'd like to mention here that a competent technician (with our approval, please) can easily alter both the input-sensitivity and impedance if our input standard is too sensitive for your requirements.

Negative Bias: Why and How

Let us begin by accepting and understanding that tube amplifiers require a negative, or polarising, bias voltage at the grids of the output stages, which is the portion of the amplifier we will now discuss. Let us also hasten to point out that the whole topic of "bias and biasing" need neither be a constant source of worry nor a bothersome continuously-required adjustment. In fact, we designed our amplifiers to specifically minimise and almost exclude this chore. (Having read and accepted the last statement, you would be forgiven for not reading this chapter any further because — we warn you! — it gets pretty involved.) The general topology and design of *all* **VTL** power amplifiers is loosely described as being of the "fixed bias" type. This follows the best traditions of American tube-design technology, which historically has been the leading-edge of the art, and which has predominantly favoured the fixed-bias topology for very sound reasons that have always interested us greatly. We'd like to share these reasons with you.

First, 'fixed bias' produces much more power (as much as 70%) at *lower distortion* than 'self-bias' at the 'design centre'-nominated value of the cathode resistor. Second, the tube will run cooler (and therefore longer) in the fixed bias mode. Interestingly, a good many outstanding early American designs from RCA, Western Electric, General Electric, and others employed fixed bias of a totally fixed and non-adjustable type. A calculated amount of negative voltage (often comfortably and harmlessly excessive) would be injected at the output grids forever, and that was that! The output tubes ran much cooler, though with minutely more crossover distortion, therefore lasting much longer. *Years* longer, we mean.

It is this philosophy that we chose to follow in our designs: we run the tubes with less standing-current but with proportionally higher rail voltages which, in turn, requires higher bias voltages which produces the desirable combination of highest power with lowest distortion *at power* while still running cool and ensuring long life. We create our bias supply by having a separate dedicated transformer winding interleaved with the "B" rail winding, which achieves the magnificent objective of obtaining a gently self-adjusting negative bias that smoothly tracks the voltage of the "B" rail according to possible variations of the line or mains voltage.

If you're wondering whether this problematic conundrum of parameters is a cinch to solve and can be looked up in a tube manual (aided by a slide rule or calculator and a ballpoint-pen) we would like to assure you that it definitely is not. Importantly, it involves the turns-ratio of the output transformer and the anode-to-anode impedance rating one elects to award a given set of output tube types. This, along with how one treats the screen grids, in turn affects the comfortable power the tubes can produce [*see* TRANSFORMERS elsewhere in this chapter]. We have evolved our own set of tube "knee" curves and tables as they relate to the type and style of tubes we use, treating the information contained in the old tube literature as approximate guide-information only — almost no two tube-manuals give the same answers and, in any case, the tubes are being made so differently from those covered by out-of-print manuals.

VTL amplifiers, with two exceptions, operate in *Ultralinear* Class A1 for *most* of their power output. The first exception in the **VTL** range is the **Ichiban**, which is pure Class A triode all the way and, at 200 watts, is not very efficient for its weight, size and cost, because one is selecting from the "linear portion" of the tube's knee-curves, only a 'B'-rail voltage of the lower order can be used, to keep the required bias-versus-grid voltage swing in the correct proportion. (This is why, say, a 6L6 pair would only yield 7 to 10 watts in pure 'Class A'.)

These last-mentioned factors are inherently a limitation of pure Class A and certainly the main reason why very few Class A tube amplifiers have ever been in commercial production: the notable American engineer, Ulrich Childs, produced one in limited quantities, Morikawa-san of Japan still builds a couple and the LUXMAN Corporation of Japan have built some smaller designs in the past, including that 8-watt single-ended version we mentioned elsewhere. The French firm Jadis builds a 160 watt unit using four pairs of KT88's; four pairs of this tube-type *can* yield 400 watts — but not in Class A!.

The **VTL** exception is the **deLUXE 120** monoblock amplifiers which are able to switch over to a half-power 50 watt Class A mode from their regular AB1 tetrode mode. Lest you think that 50 or 100 watts is possibly a little puny for your aspirations, please allow us to explain that Class A triode-watts are a whole different matter when it comes to loudness or apparent power! In a class of their own, one might say. Though fixed bias has also been used by other nations, they seemed more in favour of the alternative method of biasing, loosely described as "cathode bias" or sometimes called "self bias"; American manufacturers, wisely in our view, virtually disregarded this approach.

In clear-cut terms, "fixed bias" indicates *not* the 'Class' of operation, but that there is a fixed amount of negative voltage, by way of a separate rectifier circuit, available and intended for the output tubes' bias requirements. With the "cathode-bias" system, the output tubes get their bias from a resistor (or group of resistors in a balancing-circuit) connected between cathode/s and ground. This component was commonly referred to in tube manuals as "the cathode-resistor". Quite often the manual would quote a viable "design centre" value of resistor for the cathode under or near the heading of Class A. *However,* the mere presence of a cathode resistor (and the absence of a negative-bias power-supply) does *not* necessarily a Class A amplifier make...Many is the number of times this mistake is made, probably in all innocence, arising out of a mis-interpreted notation in the tube-manual. If you wish to study and understand correct "Class" nomenclature and descriptions, we have authoritative definitions in the appendices. We include them because we feel this is *the* single most-often confused (and sometimes downright misleading) issue ever mentioned about tube equipment.

In the high power genre of cathode-bias amplifiers our experience has been that the tubes themselves run hotter and age faster; it becomes a race (unto death!) as to how soon the tube will demand that the cathode resistor provide a greater current-flow than its wattage-rating can handle. This discrepancy will cause either the tube or the cathode resistor to burn out: the single most common failure in older tube amplifiers of this cathode-bias configuration. Installing a monster cathode resistor of, say, ten times over its calculated current rating will solve its burning-out problem, but won't address the highly undesirable under-chassis heat; nor will it change the varying current-drain by the tube.

So why did the Europeans go more strongly for this method? Well, one reason is cost, though we feel that the saving in components is so small as to be insignificant (especially when measured against later costs in tube-life and other repairs). Another probable reason is the power factor. In Europe, a 12 watt tube amplifier is not uncommon, and 50 watts is deemed to be pretty high power.

Hence on a ten to twenty-five watt unit, the cathode-bias system would seem to be acceptable. We would still elect to use fixed bias, even if the amplifier were to be of a five watt size. The American market has always favoured higher-power amplifiers which, of course, has to do with the prevailing sizes of rooms as well as loudspeaker efficiency.

When, Why and How To Set The Bias In A VTL Amplifier

The aforegoing pages on bias highlighted our design objective, which specifies that you should be listening to the amplifier in preference to measuring or worrying about the bias setting! And truly this is so — we have many amplifiers in continuous daily use over three and four years that have never had the bias re-set. It is the individual tube itself that dictates the amount of bias required, and therefore we go to a great deal of trouble and expense to fit tubes of known high and stable quality; we match them closely, culling out those that indicate excessive current draw.

The absence or large shortfall of negative bias in output tubes makes itself very apparent when the anodes (the large dark-gray portion inside the tube) start to run red-hot: cherry-red is the approved term. Not many seconds in this condition will terminate the tube. If *all* the tubes' anodes suddenly glowed cherry-red, the quick diagnosis would indicate total failure of the bias supply. Because of the design and construction of our negative supply, we can tell you honestly that this type of failure has never occurred and is very unlikely ever to occur. A much more probable cause for all the anodes running cherry-red would be serious low-frequency oscillation coming from outside the amplifier, which could "swamp" (negate) the bias [*see* OTHER ANCILLARY EQUIPMET].

We "stand" our output tubes on 10 Ω resistors (5 Ω in the older 300 and 500 watt units) which allows easy measurement of the bias current without "opening" the circuit and thereby having to rely on some jack-socket's switch-contact to re-close the circuit, and which also acts as a final fuse in the rare event of a tube going full-short internally. We run the output tubes at around 30 milliamps quiescent current, which is a reading of 300 mV across the 10 Ω resistor by Ohm's law.

There are a great many tube amplifiers around whose design calls for a much higher "standing current" as measured in the quiescent (*i.e.*, no programme) state of up to double that of ours: 60, 65, even 70 milliamps. This approach is taken to get more output power from a lower "B" rail (often 450 Volts) and to combat distortion of the "crossover" or "notch" type. We do not applaud this choice, believing that the distortion could, and should, have been taken care of elsewhere. This high-current thinking is the very thing our designs seek to eliminate; it leads to dramatically shortened tube life, hotter-running amplifiers and a bad name for tubed equipment among audiophiles and public alike. True, one can "lean down" any amplifier's bias (to a point where the tubes are just on the edge of starvation and failure) with a tiny *measurable* (not audible) decrease in distortion, particularly at lower power, but we regard this as wanton waste of tube life and totally unnecessary in well-conceived designs.

When the fitting of an entire set of new output tubes is contemplated, it would be desirable to have the bias re-set, and then only if one suspects that the new tubes were of unknown quality.

We stress and continually repeat that our equipment is only to be opened and serviced by experienced and trained personnel. If you feel you have a problem, we earnestly recommend that the amplifier be brought to a dealer or service engineer. Dangerously high voltages are present even when the unit is switched off and/or not plugged in to the wall-socket.

Output Transformers and Feedback in Power Amplifiers

"To be or not to be." — Will's Audio

"To have, to hold and to love." — Marriage Vows

A power amplifier requires DC (direct current) to operate whether it's tube or solid-state. Loudspeakers, on the other hand, require the amplification power but with a total absence of DC; and there's the rub.

We have to harness that AC voltage (the music) and present it to the loudspeaker at a workable matching impedance, and simultaneously get rid of the DC, without impairing the music. There are a few ways of achieving this: by a coupling capacitor, which can colour the music; by having a sensing circuit which identifies and cancels the DC known as a 'servo' system (but these can and do go out of adjustment and let some of the DC sneak through); or by utilising a transformer which neatly 'transforms' the AC programme volts to a suitable amount of current and makes the impedance conversion and positively will not,indeed can not, pass DC.

If a transformer is not of premium quality (and therefore very costly to make) it can also colour and detract from the programme greatly. Hence the obvious statement "If you can't have a good transformer, better to have no transformer" is very true. But *if* you can have a good transformer, there simply is no better coupling device. It is also true that to omit the transformer is easier yet with solid-state than with tubes because the output devices are at or near the common speaker impedances. Interestingly, the revered McIntosh Corporation (who set standards of build and finish in tube amplifiers of old that we unashamedly endeavour to emulate) chose to couple with a transformer when they changed over to solid-state. (Oh, rue the day! We still hold regular mourning sessions with friends who get us to up-grade their treasured antiques). Also, it is possible to choose and configure tubes to work in the mode that New York Audio Labs/Futterman chose to register as a trade-mark, O.T.L. (Output Transformer-Less); using methods of DC-exclusion commonly found in solid-state and configuring the output tubes nominally as "totem pole" cathode-followers, or cascode followers, to bring down the impedance.

This technology has been tried by all of us on the test-bench. Others have elected to market it; we have not and will not. One of our colleagues in another tube-amplifier company (we do not see our opposition as rivals; to us they're friends and brothers) who, when asked by us why he chose to build OTLs, looked us straight in the eye and said "quite honestly, because I do not know as much as you do about transformers and nor how to get my hands on good ones." That man has our respect; if he ever asked for our help on output transformers, he'd get it right swiftly. And some of the OTLs produce some pretty good sound, often outstanding sound, on their favourite 'demo' Quad electrostatic speakers. A point of interest here is that it is easily possible to tailor-connect ESL speakers very directly with tubed OTL amplifiers, thereby omitting the ESL's own internal transformer/s, often with surprising results.

The reason, we feel, that OTLs are often demonstrated with ESLs is that the 'sound' being highlighted is of the kind that one wouldn't be seeking anyway from ESLs that were un-augmented by cones in the bottom: a sweet, smooth presentation very suited to baroque music, not noted for deep, sonorous bass content. The why of this is not hard to find either: the ESL does not go all that low, so the ultra low impedance that a dynamic speaker reaches on extremely low-frequency information which could embarrass the OTL does not arise (and the demonstration will not include a thundering pipe organ with 26 cycle notes).

OTL amplifiers suffer when the impedance drops to very low values. Published specs state "100 watts into 8 ohms, 35 watts into 4 ohms" and the (unpublished) information would continue "20 watts into 2 ohms" et cetera. But the matter of the loudspeaker's propensity to decrease in impedance as frequency is lowered does not end with OTLs; it affects transformer-coupled tube amplifiers too, but to a much lesser degree. It affects solid-state amplifiers too, but *incrementally* as we all know from reading the ads and specs. Such as in the hypothetical (but true) promise: "100 watts into 8 ohms, 200 watts into 4 ohms, 400 watts into 2 ohms." This is meant to maximise, truthfully so, the subject solid-state amplifier's power capability into (nominal) speaker impedances, because being current-producing devices, transistors do operate this way (as per Ohm's Law).

It is probably quite clear that we have a preference for output-transformer coupled amplifiers since we have made a specialisation of their design and how to build them. We go to great expense designing and winding output transformers up to and beyond the specifications laid down by Williamson; the shorter cuts and 'quickie' methods of design and execution don't produce the results that we or you are looking for. Designing an output transformer, particularly the high power models, presents the ultimate "Catch-22": you need to handle very low frequencies at high power, so mandatorily (in terms of power, or watts) you need to make it big and heavy with high flux-density. As you start to get bigger, so advances proportionately the squeeze on the high frequencies; understandably, the magnetic 'window' is increasing with the diameter of the bobbin, the distances are getting greater, leakage-inductance starts going up and the upper frequency-response starts to go down — out the window, we say. To combat this war that physics wages on the designer, he has to rely on precision hand-work in the actual winding of the unit's bobbin. In the hand-winding stage of a high performance audio transformer (though a motor actually rotates the bobbin for reasons of speed constancy) portions of the primary (input) winding are interleaved with portions of the secondary (output) winding and again, sub-portions of the various portions of a given winding are laid down, like fingers on a hand when moved close together, and this is known as bi-filar and tri-filar winding (when three windings are so laid). Doesn't sound all that difficult, does it?

The real problem comes in the planning of the winding-design so as to split the sections in such a way that the multi-split (ever-changing in diameter, and therefore length) is evenly shared over the sections so that each row (as in knitting) is exactly and evenly filled. So when we talk about "nineteen sections", remember also that every interleaved section is separated with a thin insulation dielectric. This must not have the merest hump or surface unevenness to present to the next winding, because a loss of high-frequency information will occur through leakage-inductance. All in all, we are talking of a very carefully conceived and executed piece of art.

Having conquered the problem of size hurting top response through leakage inductance and other pitfalls, we routinely build our transformers to exceed nominal power by fifty percent and the frequency response to go down cleanly *at power* to two octaves below what is considered to be the bottom limit: 20 cycles (Hz) — one octave lower than that is 10 cycles, and one octave lower yet is 5 cycles, the power spec to which we work. The theory and practice is that we want the amplifier to produce tight, clean bass at the frequencies that involve you and the loudspeaker, say 30 cycles; we therefore have to get the unit to start getting control at the so-called sub-sonic frequencies. Then at the point where the music enters the loudspeaker's realm, the amplifier has gotten rock-solid control of the bass.

As you will see, negative feedback is importantly related to this discussion because it affects overall performance of the transformer and its output impedance.

First a little background: the benefits of overall negative feedback were first documented by a young engineer, Harold S. Black, in 1928. He found that vast improvements in linearity and distortion could be achieved by taking a small portion of the output and re-injecting it back into the front or input of the amplifier. Feedback started to appear in many units made by professional equipment manufacturers such as Western Electric in theatre amplifiers before World War II.

This idea of inducing feedback was not the first knowledge of the principle, for when the American Lee De Forest first "upgraded" (you see they were at it already!) Fleming's simple diode by adding a grid to make the first viable triode, he soon discovered that the tube inherently had 'internal' feedback, and the benefits were noted. Later designers like Williamson (in 1947) showed elegant ways of sampling the feedback and re-introducing it to the cathode, and also proved that a discreet amount (under 20 dB) of feedback (like spices in food) was good, though too much caused phase-shift and 'slowness' or poor transient response, among other things. Much later still, early designers of solid-state equipment, struggling with the new technology, quickly spotted that a surfeit of feedback (40 to 60 dB) could be very useful in panel-beating lousy circuitry into some sort of reasonable-looking measurements (on the 'scope, not the ear) and negative feedback started to gather an unsavoury reputation.

Negative-feedback (always we stress: used in sensible quantities) has a greater influence than would seem apparent on matters of output and output-transformers. It majorly reduces output impedance when taken from the 'driving' secondary winding, in our case reducing the nominal impedance to less than one tenth of an ohm. This increases the amplifier's damping-factor to what we feel is optimum at around 25/35. (And a very controversial subject is this matter of damping-factor! *True* damping factor is too complex to go into deeper in this treatise.) Yet more importantly, by having the feedback coming from the high end of the winding that is actually connected to the loudspeaker, one is able to an extent to embrace both the speaker *and* cable within the feedback loop with very beneficial results. This phenomenon arises by 'back-EMF' (electromotive force emanating backwards from the speakers' magnetic motor) and is more complicated yet to explain herein.

Because we use this feedback-lowered impedance and transducer-embracing EMF to good advantage, we do not have our transformers wound 0, 4, 8, 16 or 0, 2, 4, 8 ohms as presented taps; our system requires that the entire transformer be included in the loop. When you have a 0, 2, 4, 8 tapping approach and the speaker is connected to 4 ohms, say, the feedback will be connected to the 'high' or 8 ohm tap, leaving that distance in the transformer secondary. Move the feedback link down to the 4 ohm point where the speaker is attached and you have the rest of the transformer "flapping in the breeze" — and *wasting* valuable current (Amperes!) that could and should be channelled into the loudspeakers.

We, like Williamson, have a multi-section secondary and we combine these sections in series-parallel inside the transformer for maximum effect. In the case of our transformers of 100 watts and up, we bring these points or taps out to external lugs marked A through H, so that the connection/s can be made to suit [*see transformer drawings in the Appendices*]. Another reason why we don't subscribe to the 0, 2, 4, 8, method, and this is vitally important, is that when then output impedance is altered to another value *so accordingly should the feedback be changed,* to optimise the interface: and you can't do that with a screwdriver. While it would seem obvious that 4 ohms is half of 8, that unfortunately is not the way of it: in impedance calculation and measurement, 4 ohms is seven tenths of 8 ohms and so on.

What of the so-called 'hybrid' designs, which employ a mixture of tube and solid-state technologies? Well, this leaves us in a head-shaking state of bemusement! It would seem that one school says that nothing is as good as tubes in the front-end driving a solid-state output-section while the other school says that tubes have no equal as output devices (in normal transformer coupled mode) yet believe that solid-state has the edge as input and driver cicuitry. For the record, we confess to having experimented with both variants and long ago decided that neither equals, let alone beats, pure legitimate tube technology. The Radford company in England brought out their TT 100 some fifteen years ago which had a transistorised front-end driving KT88's, and the comparison between this beast and their regular STA 15's and STA 25's was something frightful to behold. Our knowledge and experience of hybridization in professional equipment, too, has always seemed to tell us that a gap has been found in design and construction that saves a bunch of money.

The Ultra-Linear Aspect

All of our power amplifiers (except triode units as noted) employ this excellent output transformer concept. The idea was brought to new attention by Messrs. D. Hafler (the same David!) and H.I. Keroes in 1951 through the pages of the journal "Audio Engineer". Invented in 1937 by that titan father of stereo itself, Alan Blumlein, the method was known in Britain as "partial triode operation", which explains itself rather clearly.

In standard operation, the screen-grid of a tetrode or pentode is connected to the 'B' or high-voltage rail (or a separate and possibly regulated 'B' is created for it). The tube will give its maximum power with a somewhat higher (though very small) amount of distortion. When the screen is joined with the anode or plate, the tetrode functions in triode mode, yielding considerably less than half power, but with the triode's lower distortion. "Partial triode" positions the screen grids at a point (a tap in the transformer primary) somewhere in between the anode and the centre-tap (the 'B'-rail); the closer this point is to the anode, the closer the tube behaves as a triode. Going closer to the centre-tap produces more of the tetrode performance.

What seems to be not generally known in some quarters is that the 'magic point' differs for the various types of output tubes and the class in which they're positioned; also the extent to which the screen grid then functions as 'more metal' to the anode and affects the permissible class and voltage maxima of operation. When the screen is at some mid-point, the tube is functioning as a tetrode basically but with internal negative feedback applied to the screen. We have carefully selected the percentage of primary used in our ultra-linear designs to maximise power output without giving up the triode benefits; though we choose not to disclose these ratios [*see* TRANSFORMER SCHEMATICS].

The Life and Availability of Tubes for VTL Equipment

As thoroughly trained design engineers who have made a life-long study of tube equipment, we find this a particularly irksome subject. A question (statement, sometimes) such as "...and tubes don't last very long, *doooo they?*" from an unsuspecting member of the public (who is often under 25 years of age and has never owned tube equipment, or definitely not ours) is apt to make us reach for the telephone to ask our lawyer if he is prepared to defend a charge of willful AGB (assault with intent to inflict grievous bodily harm).

Whence cometh this uninformed misconception? Don't people remember (or talk to older family members who do remember) how reliable and trouble-free the radios and phonographs of the Thirties, Forties and Fifties used to be? Many are still in use today by some of our Grannies and Grandpas. Don't people know that almost all professional musicians use tube amplifiers (and these are manhandled in the roughest ways) to earn their living on the road? Don't people know how many cinemas, drive-in movies, small churches, meeting and concert halls, broadcast stations, ham-radio transmitters, telephone link-ups, or how much medical, measuring and navigation/radar equipment depend on tubes for maximum failure-proof service? Is it not well enough known that Soviet Russia uses almost exclusively tube equipment for military and strategic communications? (In point of fact, their reason for this is mainly the tube's ability to stay operational in nuclear radiated areas — so you'll make sure that when you plan your next fall-out shelter, you'll fit it only with tube equipment.)

Oddly enough, it would seem to be fixed in some people's minds that because a tube can be readily unplugged and replaced upon failure, it follows that frequent failure must be part of the scheme of things. Yet wouldn't the same folks be absolutely thrilled if they knew that a brand-new motor could be instantly plugged into their automobiles at low cost and without tools or specialised knowledge? That they could in fact perform the switch themselves?

Yes, it is true that there has been unreliable tube equipment (as there have been unreliable cars, computers, refrigerators, solid-state amplifiers, cassette decks, and so on). But those products have, by and large, fallen into the following categories:

1) equipment from smaller firms which have not had sufficient design knowledge, nor the money to get such knowledge;
2) equipment that has been vastly over-complicated (often with much solid-state hybridization), thereby getting away from the inherently advantageous circuit simplicity;
3) equipment that has been "designed down" to a price point, thereby compromising the quality of many components that surround the tubes;
4) equipment that has utilised poor-quality tubes, which, make no mistake, did and do exist.

If one looks back to the time when manufacturers such as Marantz, Fisher, Scott, Brook, McIntosh, Harman-Kardon, Dynaco, Leak, Lowther, Luxman, and Lansing (to name a few) were in full amplifier production, can one honestly say that unreliability was ever really a major factor?

You see, if one takes a given topology for, say, a given gain stage (*e.g.*, an input triode) which would consist of a tube, a socket, an anode resistor, a grid-load resistor, a cathode resistor and probably a decoupling capacitor, plus a coupling capacitor to the next stage, there is no way it can or will fail (provided, of course, that the wattage and working voltages of the resistors and caps are correct). Now, though, try surrounding the tube with solid-state technology: current-source the anode with a Darlington-pair, ditto the cathode and top it off with a complex regulator for that stage only. Then when (not if) it breaks down, you'll be able to say that tubes are unreliable! Moreover, it will not sound like a tube while it is working.

The same is true for an output stage (or stages) if the tube is being asked to run at a higher current (heat, therefore) than that for which it was intended. It is very true that more poor-quality tubes abound nowadays due, obviously, to the tube's being the less commonly used technology and because some top-class manufacturers have shut down. Sadly, it was the so-called "smart" countries that raced out of tubes first. Good tubes are damned hard to make and are akin to analogue mechanical watches. [Remember them? You used to wind them up and they never gave you any problems.] This is because the factory must be staffed by a large number of nimble-fingered, dedicated gnomes wielding tweezers and wearing eye-pieces.

Tube Types We Use, And Some We Don't

Fear not, very good tubes are still being made; in America, we have become very close to MPD (successors to the General Electric plant) whose products are distributed exclusively be Richardsons, a multi-million, enterprising firm that has offices and warehouses world-wide. The Richardson Corporation saw the vital importance of continuous quality-tube supply early on in the game and, as and when certain plants ceased production, Richardsons has picked up the tooling, moved it to La Foxe, Illinois, and kept strategic types continuously in production.

One of the key aspects of **VTL** equipment is that we design for tube types that are easily available from known premium-quality sources; and besides the premium sources we prefer, our chosen types also have alternative (but lesser quality) options available world-wide from other factories.

The GE-MPD factory worked continuously with us to produce a **VTL SQ** (Special Quality) 6550A — the "A" version is 15 to 20 percent more in anode dissipation (42 Watts) than the regular 6550 (35 Watts) and GE-MPD are the only people in the world able to build it. We fit this tube standardly as well as the GE 6CA7/EL34. The latter piece is even more rugged than the historic British Mullards we started with. GE also builds our favourite 6201's (the military version of the 12AT7) and our 12BH7 driver tubes.

The mainland China Shugang factories (and affiliated brands) build an excellent 12AX7A to a continuous quality that has almost become an industry standard. We have put hours of testing into their output tubes too, but so far remain unimpressed with them: they have neither constancy (sample to sample) nor longevity when used at or near rated specification. They do *not* offer a genuine 6550 yet, preferring to use a KT88 variant-structure in a bulb marked 6550. (The M-O Valve company authorised the Chinese to build the KT88 when the British factory closed — but the new version doesn't get close to the original on *any* parameter. In any event, the 6550 and KT88 *are* different, though they do have some similarities.)

One can often fit a KT88 (a beam tetrode) in place of a 6550, but seldom the other way round. The KT88 was designed in Britain using the American 6550 as a model, but was built more ruggedly and can take very much higher voltages on its screen grid and anode. The KT66 has similar ruggedness and can approximately be compared to a 6L6 and an 807, though both the KT66 and 807 types can handle higher voltages and power than the 6L6. The 7027A was closer in beef to the '66 and '88, but is now hard to come by in its original form, having been approximately replaced by the newer 8417.

A word here about tube qualities, even those bearing the identical type number: the EL34/6CA7 is a prime example. This tube was one of the last to be designed, and went into near-simultaneous production all over the world. There was an industrial version made by Siemens & Halske of Germany that was so ruggedly built one could push the anode voltage up to around 1000 volts and get close to 100 watts from a single pair! The average tube manual shows a maximum design-centre voltage of 800 volts: but this will refer to a premium American or British piece. However, there are two or three East European examples of these types that are visibly slimmer and lighter in internal construction, known in the trade as "Continental Slimmies". Some of this style of EL34 are fairly well-made, but simply not comparable with the best of British or American items. Apply 800 volts to the anode and, as they say on Brock's Crystal Palace fireworks, "stand well clear!"" We run EL34's at 500 or 525 volts.

It is because all of our designs run their tubes so conservatively that they run so cool and stay working so long. If in a pinch you fit some "Slimmies" to a **VTL** unit however, you will get neither the power output nor the longevity of the original tubes fitted by us. Other tubes we have used are:

8417: A truly fine output tube though not, in our view, widely enough available.

EL84: (US equivalent 6BQ5.) A nine-pin miniature Noval, commonly regarded as the smaller brother to the EL34, and electrically similar to the older, octal 6V6. The EL84 was used in some of the early **VTL** models (16, 25 and 30 watts) and we will return to it at some time.

7868: A tube in a large-miniature Novar nine pin base which we highly favour. No other type substitutes for this base-wise, and were becoming harder and harder to obtain.

KT66: (Well, not exactly, but...) we have recently sourced a Russian military-grade substitute — close to a 5881, but with higher maximum permissible voltages. We are very pleased with this tube and feature it in our "Custom" 80 Watt monoblocks.

KT88: Oh, what a tube this was in its prime version: only made in Britain by Mullard-Osram and co-marketed as the Genalex "Gold Lion". Even in the final couple of years before M-O's closing in June 1986, the quality had started to slip due to imperfect machinery and dwindling personnel.

EF86: One of the best miniature pentodes ever. We do not favour pentodes as an input or preamplifying device because of noise and distortion.

6L6: (Also available in heavier duty versions suffixed 'G' and 'GC', as well as the smaller-enveloped 5881.) The 6L6GC is as tough as the proverbial army boot and will deliver good clean power for ten years and more in musical instrument amplifiers. Yet, apart from older equipment such as McIntosh, almost no current high end items utilize it. Most likely the reason lies in fashionability among the designers and audiophiles who perceive it as a workhorse guitar tube. We offer the 6L6 as an alternative in our triode/pentode-switching model **deLUXE 120 Monoblocks** for those who prefer not to have the anode-capped 807's. The Cathode-less triodes type 6B4G, 300B, 211 and 845 are somewhat more of an aficionado's tube, and are not that easy to source, but well worth the trouble!

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Owner's Manual Section

Vacuum Tube Logic of America thanks you for selecting our tube electronics for your stereo system. In the interests of getting the best performance out of your equipment, may we ask that you take the time to read through this manual first, please? if you wish to know still more about us and all our equipment, you might consider investing in a copy of *The* **VTL** *Book*: if so, please write enquiring about ordering it.

Much of the information contained in this little manual has been accessible only in technical literature long out of print. Some of the concepts and ideas have never appeared in print at all. Most has been gleaned from 30 years in the professional recording industry, wherein we have proven out our circuitry and design philosophies. We hope therefore that you will find yourself both informed and entertained.

This is about the exotic and beguiling hobby (art, one might say) of attempting to create the illusion of live music in your home. Before going into any technological details about Vacuum Tube Logic equipment, it might be in order to state that our on-going goal is to offer discerning audiophiles premium-quality, musically accurate equipment at a price that allows us to earn a conscienable profit, and to produce this equipment with a fierce pride. It is this pride and dedication to quality (and reliability) that makes it possible for us to offer our (conditional) lifetime warranty — quite possibly one of your major reasons for choosing **VTL** equipment in the first place.

We believe deeply that well-designed and executed vacuum tube electronics have continuously demonstrated their musical superiority over other technological breakthroughs. No question, the transistor is an invention that borders on the miraculous; but we believe it has its best uses in computers and calculators, radios and robots. Ask the musicians; hear the truly great recordings made with famous tubed microphones; pay heed to the (oh so rare) knowledgeable reviewers. But then just listen, and you'll know.

True, tube equipment has never been inexpensive to buy; and true also that a very good value-for-the-money deal is available to the consumer nowadays when purchasing a $300 stereo rack from a department store — a direct result of the low-cost transistor in mass-production.

Such mass production, of course, is not without its price. Nothing will demonstrate this more than actually listening to our equipment, and seeing (hearing, feeling) this for yourself. Quite frankly, the difference is not subtle.

Power Requirements

All **VTL** equipment is designed to operate on the various AC voltages around the world. The mains transformers in our units have multi-tapped dual primary windings (for series or parallel connection) that use the following color coding:

Power Transformer Color Code		
Volts	Primary 1	Primary 2
0	Black	Orange
100	Brown	Yellow
120	Red/White	Blue/White
127	Red	Blue

Hence any line voltage from 100 to 254 volts can be configured; some examples: black and orange are joined together as 0 volts, with red/white joined with blue/white as 120 volts to form the standard U.S. mains/power input, putting the two transformer primary windings in parallel. For 240 volt operation, the primaries would be connected in series, with black alone being 0 volts, red/white (120 volts) connected to orange (0 volts of the second primary) with suitable insulation, and blue/white being the 240 volt termination.

From these examples, it can be seen how 100 volt operation (Japan) is connected in parallel, and how 220 volt operation (most of Europe) is achieved with the primaries in series. Of course, we do not classify this operation as a modification provided it is undertaken by a qualified technician or a competent dealer.

However, we stress that the equipment should not be opened for any reason by anyone other than experienced, qualified technical personnel. Tube equipment contains extremely high voltages — 400 to 600 volts Direct Current — which can cause a nasty or even lethal shock long after the unit has been switched off and disconnected from the mains supply. This is due to the inordinately high capacity banks utilized in **VTL** equipment. A trained technician knows how to safely discharge these capacitors before commencing any work on the unit. From the user's viewpoint, our equipment is totally safe to operate and is extremely reliable under normal conditions of usage, provided only that it is not tampered with by unqualified persons.

General Operational Notes

We do not recommend that the equipment be left permanently switched on, only for the reason that this is wasteful of both electrical energy (money, therefore) and tube life. You will find that **VTL** equipment sounds excellent right after switch-on, though of course we agree that all equipment improves sonically after a longer warm-up period. Interestingly, it is not the tubes themselves that benefit from the longer warm-up (they come up to peak operating temperature after four or five minutes) but the temperature settling of the capacitors, resistors and the wire in the circuit itself, plus the transformer's wire and core material, that enhances sonic performance after the equipment has thoroughly warmed up.

On the subject of mains/power, please do not be alarmed when some of our larger power amplifiers emit an audible acoustical "thump" on switch-on. This is caused by the residual magnetic energy in the power transformer as it undergoes pole reversal. Likewise, the seemingly over-bright "flash-glow" upon switch-on of the smaller (input) tubes is no cause for concern. This is the result of their heaters being cold, and hence of lower initial resistance. Also, the 12– series of tubes has a greater portion of the heater winding exposed (*i.e.*, not inside the cathode enclosure).

Always install our (and other) equipment with sufficient air space around it. We disapprove strongly of stacking, and the shapes and sizes of our various models are specifically designed to prevent stacking.

If you prefer to see and commune with the warm, friendly glow of the amplifier tubes (we do), there is no harm in operating the amplifiers open topped, but we suggest then that you fit our finishing brackets (which are neither intended to be used as nor called "handles") which serve the dual purpose of giving the unit a finished look and affording some protection from feather-dusters or flapping dust cloths. Also, we think it would be obvious not to floor-mount the amplifiers if your family includes toddlers or pets. Strange, is it not, that some people who would not leave a delicate instrument such as a fine camera lying around for fear that a child or dog might damage it will exercise no such common sense when that fine instrument might instead damage the child or dog.

Other Ancillary Equipment

Though we dearly wish it otherwise, we cannot insist that our power amplifiers be driven only from our own preamplifiers. We do not, however, think it requires a great deal of understanding to conclude that our designs are conceived to perform at their best in concert, so to speak. But for those who do, for reasons of their own, choose to "mix and mismatch" various brands and designs, let us please spell out parameters.

First, though this was not intended by design, most **VTL** preamplifiers will drive almost all other amplifiers, even solid-state, to a lesser or greater degree of success. Matters of impedance-matching and drive-voltage requirements *do* have to be borne in mind, however, especially with some solid-state amplifier equipment. In the latter instance, a coupling-capacitor is often part of the *amplifiers'* input circuitry. Even though an acceptable impedance match (commonly in the 5 k, 10 k, or 20 k vicinity) will occur, this capacitor *may* be of too low a capacity to allow full low-frequency response from the *very low* (about 30 ohms) impedance of our most senior models (**SuperdeLUXE**, **Ultimate**, and **Manley Reference**) of preamplifier. The only solution is to change the capacitor in the 'foreign' amplifier to one of higher value on the order of 10 microfarads. Our **Maximal** preamplifier was specifically designed to drive *tube* amplifiers and has an output impedance of approximately 5 k, so it too can be used with many (though definitely not all) solid-state amplifiers.

If you want to put a tube preamplifier in front of your favourite solid-state power amplifier (and yes, we do commend your thinking) the best-suited to all is our **deLUXE** preamplifier (available with and without MC stages) because its main-buffered output is on the order of 300 ohms — the ideal solid-state match.

All pure-tube amplifiers are upward of 50 k input impedance, a so-called "bridging input" in the sense that the amplifier presents little or no load to the preamplifier output.

As regards input sensitivity, however, **VTL** amplifiers are somewhat more sensitive (easier to drive) than others, requiring approximately 800 millivolts rms for full output. This thinking is planned around the "dBm Standard Scale", whereas there are many amplifiers around (mainly of older design) that have a full-power drive sensitivity of 1 volt up to as much as 1.8 and even 2 volts rms. These are designed with the "dB Standard Scale" in mind. The point here is one of gain scaling (sadly, an almost never discussed subject) wherein one learns to apply the benefits of judicious component matching. Consider a (hypothetical) worst case: a lower-output moving-coil cartridge with, say, only 0.3 mV output chosen to drive a preamplifier that is optimised for cartridges of 0.5 mV upwards, which is now interfaced with an amplifier requiring, say, 1.8 volts of input to drive it to full output.

Painting the picture even darker, let us say the preamplifier was optimised to drive a 1 volt senstitive power amplifier of, say, only 50 watts power output at 8 ohms (nominal) loudspeaker impedance. You can see where we're heading, but let us worsen the proposition further by adding that the loudspeakers chosen to complete this disaster were to be of the 4 ohms variety (not the 8 ohms the amplifier was configured for, thereby reducing its power by 25%) and then let us nominate that these loudspeakers were only of 84 dB efficiency at 1 watt at 1 metre. There's a word to properly describe such a system, but the writer is too refined a fellow to even think it. Now it can be plainly understood that this system would suffer in the worst way from poorly chosen interfaces as regards gain-scaling, as well as power/impedance/efficiency mismatches that would result not only in disgusting sonic performance due to wrong (insufficient) excitation voltages, but also in unacceptable noise levels.

To complete the topic of interfacing **VTL** amplifiers with other preamplifiers, we must include sundry active gain-bearing crossovers, "equalisers" provided by some loudspeaker manufacturers (many of which should more accurately by described as "design deficiency correction devices"). We need also to explain one of the most worrisome problems often encountered with incorrectly chosen "other brand" preamplification equipment. This concerns the matter of DC voltage present at/in the outputs. An alarmingly large proportion of preamplification equipment evinces this defect: the most common offenders are the more complicated designs wherein some foxy servo circuitry exists for the express purpose of "servo-ing" the DC.

Just as bad (though this is a less well perceived and understood problem) is the presence of instability, which manifests itself as oscillation at an extremely low frequency, usually under 10 Hz. Though small in magnitude, this is able to pass through the coupling capacitors because of its ultra-low frequency (close therefore to pure DC). This AC signal, now masquerading as quasi-DC, enters our **VTL** amplifiers, whose design criteria specifically demand that the power band pass be extraordinarily wide. As a result of this, we can promise our much-admired tighter-than-solid-state bass. So this spurious oscillation progresses, with ever-increasing amplification, right up to the output tube's control grids, whereupon it "swamps" the essentially required negative DC bias voltage. Starved of bias, the output tubes will glow cherry-red on their anodes (plates) causing them to self-destruct.

Now do you see why we refuse to grant any kind of warranty on amplifier tubes when the unit is not driven by a **VTL** preamplifier? You might not agree, but you'll surely understand our reasoning.

The VTL Range of Models

We take a fair amount of criticism for producing a large number of different models, mainly from people who have a particular axe to grind. And yes, it's true that we could make more money and have an easier life if we just made one amplifier and one preamplifier. Our reason for offering such a wide range of models is based on our policy of making audiophile quality available at all price levels. People tend to think of tube equipment as the highest of the High End and priced as such. We take great pleasure in offering premium musical reproduction to the discerning but less-affluent audiophile, as well as catering to those not restricted by budget.

The Maximal

The **Maximal** has small screwdriver-adjustable potentiometers on its rear panel, which gives an increase/decrease of almost 5 dBs on each channel to better enable its usage with a wider variety of cartridges and amplifiers. As a secondary function, this little pre-set helps adjust the balance control to be 'centred' in its mid-position.

The topology of the **Maximal** is two 12AX7A triodes per channel for the PHONO section with 'active' RIAA and two 6201/12AT7WA triodes per channel for the LINE section , with the selector switch and volume control being electronically located between the phono and line stages. The 'line stage' has a tasteful amount of overall negative feedback; this loop includes both the balance control and the pre-set adjustment. Certainly, it was not designed for the very low-output moving coils, but it will accept all but the extremely low-output cartridges (under ,15 mV) by the extension afforded by the rear pre-set adjustment. N.B.: The pre-set is factory set in its "mid" position and also for accurate balance control positioning; *do not alter the settings inadvertently* — do so only when wishing to reduce or increase gain for matching purposes.

The **Maximal** has an extremely "stiff" B-rail power supply (over 1000 microfarads), and a regulated 12 Volt DC supply for its tube heaters.

The deLUXE

Our second preamplifier is called the **"deLUXE"** in our literature, though many call it the **"American deLUXE"**, because it was the first model we manufactured in the USA, and to distinguish it from its older **"British deLUXE"** brother. It is from the **deLUXE** preamplifier that the family topology starts to develop in our range of four preamplifiers. In its standard and simplest form, the **deLUXE** offers the following facilities: AUXILIARY, CD, TAPE and TUNER as line-level inputs plus, of course, the PHONO input.

Let us examine the PHONO input first as to its intended cartridge matching and best utilization. The input here is designed to be pretty flexible as regards moving-magnet and many moving-coil cartridges and, believe us, this was a tricky problem to tackle [*see* PREAMPLIFIERS]. The PHONO input is loaded with the recognized standard 47 kΩ load-resistor.

Impedance and loading considerations aside, the **deLUXE** has sufficient gain *when used with one of our amplifiers* to handle most, but not all, moving-coil cartridges down to about point-five millivolts, and even to point three, with an acceptable noise-floor. However, we would call less than 0.5 mV distinctly marginal; perhaps not for reasons of noise, but certainly of insufficient excitation voltage.

Optional MC Step-Up. We believe the only proper way to deal with low-output cartridges is to have a dedicated stage to boost them right at the input, which is why we offer this as an extra option on all our true High End units, which include the **deLUXE**. Note that this addition is *not* a retrofit option, because in the **deLUXE** the MC step-up is hard-wired in (*i.e.,* not able to be instantly switched out/over to MM/high-output 'coil mode as in the **Super deLUXE** and **Ultimate**).

So if a low-out MC is in your present or future, it is smart to order the **deLUXE** with the MC stage built-in; even though it is hard-wired into the circuit, a competent technician can by-pass the MC stage and put the unit into the MM-mode. Equally, the MC step-up can be re-connected later with some precision soldering.

Besides the input options, our **deLUXE** is pretty unique in that it offers *three* outputs which can all be used simultaneously if desired:

a) The RECORD out in the main socket cluster comes from the selector-switch, so it can drive most high-impedance tape-decks. Since this point is also at the "top" of (*i.e.,* before) the volume-control you should disconnect your recorder's input if you know it to be under 100 kΩ input impedance when you are not actually tape-recording, because it will load, and therefore impinge, on the sound of the repro-system.

b) The HIGH-IMPEDANCE output (the last pair of sockets in the main cluster) comes from the line-amplifiers final anode. It has therefore the fullest output voltage available from the preamp, but at a relatively high impedance: approximately 10 kΩ. It is a very useful output indeed when used with high-quality interconnect cables over a distance of no more than ten feet or so, **but only into a VTL tube or other tube amplifier** of no less than 50 kΩ input impedance. **This output should not be used with any solid-state amplifier.** The reason we offer this HI-Z out is twofold. Firstly it is "good for sound" to avoid the cathode-follower (buffer) stage if you can because cathode-followers have an insertionloss of about ten percent, and this extra ten percent will improve the signal-to-noise ratio; besides that, any stage that can be left out is a great stage to leave out. Secondly (nobody ever spots this), the HI-Z out can be used — with a specific high-pass series-capacitor — to drive the mid/treble *tube* amplifier of a bi-amp'ed system, thereby leaving...

c) The LOW IMPEDANCE cathode-follower output (the pair of sockets on their own at the rear right) available to drive the bass amplifier, which could be tube or solid-state since the impedance at this output termination is of the order of 300 ohms. The LO-Z buffered output of the **deLUXE** can drive any amplifier over any length of cable.

A unique feature of all the **VTL** preamplifiers is that the balance control functions via the feedback loop and not by way of an additional half-set volume control in the signal path, the more commonly used method of controlling balance that certainly impinges itself on the signal. The separately-cased power-supply for the **deLUXE** is mounted on the common 19-inch panel but offers the desirable benefits of an outboard supply for EMI isolation (hum and other interference).

The power-supply for the **deLUXE** drives both channels; the 12-volt DC rail for the heaters is fully regulated, while the high voltage (B rail: approximately 260 VDC) achieves its regulation through its massive capacity bank and pi-filtering, which totals 1280 microfarads — a Joule-content not found in many power amplifiers, let alone preamplifiers.

The topology overview then for the **deLUXE** consists of (per channel): a pair of triodes, in cascade with each channel in a separate envelope, which comprises the phono-stage with the RIAA actively embracing the pair (by selective frequency feedback [*see* PREAMPS]) entering the selector switch and volume control, then into the line-stage which comprises another pair of cascaded triodes also embraced in a discreet feedback-loop which contains the balance-control. At this point the high impedance output is available before the signal enters the final cathode-follower buffered (low impedance) output.

We intend the **deLUXE** preamplifier to be used in systems which are limited only by the quality-cost, therefore, of the cartridge, arm and turntable. By this we mean that we don't envisage a Lapis Lazuli cartridge on a Goldmund Reference table driving a preamplifier in the thousand-dollar bracket: however, if someone chose this match, we would neither laugh nor be embarrassed.

The Super deLUXE

Our third unit is called the "**Super deLUXE**" in our literature. The **Super deLUXE** is most closely related in topology to the smaller **deLUXE** and the older **British deLUXE**, but with more features and refinement. The more important of these are:

a) Each audio channel is complete on separate boards mounted several inches apart.

b) The preamplifier has an outboard (single circuit) power supply interlinked with an umbilical cord; the intention being to locate the power supply for lowest noise pick-up by the PHONO cables.

c) The **Super deLUXE** is standardly built and offered with a switchable (in or out) MC step-up stage which has selectable cartridge loads. We list the **Super deLUXE** as being available for MM only, at three hundred dollars less, but we have had no call for this — probably because users of not-the-most-expensive MM cartridges correctly choose the **deLUXE** and those using the most costly MM (or a pricey high-output 'coil) go for the **MC Super deLUXE** or **Ultimate**.

d) The **Super deLUXE** has a totally buffered (separate cathode-follower) low-impedance RECORDING output capable of driving any recorder (even 600 ohm studio-line) or outboard amplifier/surround-sound device (or even a dead short) without loading the main signal path in any way.

Please do not attempt to engage the MC stage (on older SDL models with internal switching) — or even open the case — unless you are somewhat of an advanced amateur technician. Dangerously high voltages are present inside our preamplifiers, even many days after they have been switched off, because of the energy stored in the extremely high-capacity banks. If you are the kind of person who does not cope well with electrical matters like the changing of a household fuse, please take the unit to your dealer to effect any change-overs. The **Super deLUXE** preamplifier is routinely shipped in a moving-coil mode set to handle any MC cartridge.

The MC stage's selection and load-switching requires some careful understanding. First and foremost, please know that it is unique in that it does not invert the phase; *all* step-up transformers do, as do other outboard tube set-up pre-preamplifiers. Inside the case at the left and right rear of the mother board there are two blue DIP switches with contacts numbered 1 through 8, selectable as follows:

DIPS 7 and 8 (together): switch the MC stage into the circuit. In fact, either one does this and the switch has very high quality gold contacts; we just use two to increase the contact integrity.

DIPS 1 through 6 (separately and/or together): starting from 100 ohms (DIP 1) and increasing in values up to 4700 Ω (DIP 6) these switch in the loads which, of course, also affect the gain. The loads are applied in parallel so that by, say, switching all the DIPs to "on" you would have 100, 470, 1000, 1000, 2700, plus 4700 ohms all combining in parallel which will bring the lowest value

(100 ohms) down to around seventy ohms — an extremely low load indeed [*see also* CARTRIDGES]. The following formula may be used to determine the exact loading:

$$R_{Total} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_N}}$$

So in the abovementioned example where all DIP switches are selected, the total resistance would be

$$R_{Total} = \frac{1}{\frac{1}{100} + \frac{1}{470} + \frac{1}{1000} + \frac{1}{1000} + \frac{1}{2700} + \frac{1}{4700}}$$

This gives a total resistance of

$$R_{Total} = \frac{1}{0{:}01471} = 68 \text{ Ohms:}$$

Notice that, since we're working with reciprocals, the larger values (*e.g.*, 2700 and 4700 ohms) bring down the total resistance less than the larger values. The above formula is included only for the sake of completeness; we recommend that you let your ears decide what is best in your individual situation.

The point is that regardless of what any manufacturer offers as what they *know* to be the optimum loading for a given cartridge, most audiophiles prefer to disregard this information and go with what sounds best in their actual system. As far as cartridges go, we actually agree with this philosophy, because cartridges are delicate little devices that vary greatly from (new) sample to sample; they age or "burn-in" differently, can be easily damaged in a marginal way that affects their sound performance and produce totally different read-outs with various arm-masses, VTA,tracking-weight et cetera.

So regardless of the stated load for a specific cartridge, the setting of the DIP switch will be mainly chosen by ear. No harm can be done; we send the units out selected for a load of approximately 400 ohms, which seems to us a reasonable average for most MC's. Again, and we never underestimate this concept, let us suppose that yours is an ABC cartridge which the maker and common opinion agree is best loaded by XYZ ohms; but you happen to have a DEF amplifier driving GHI loudspeakers via ZIP cable... The net result could easily be that by switching in, say, 100 ohms of load to a cartridge designed for 1000 ohms that a preferable overall sonic balance was achieved in that particular system and room. Who could argue?

The Ultimate Preamplifier

Yes, we take a fair amount of 'stick' for the immodest-seeming name we bestowed upon this unit. But we can explain! By 'Ultimate', we mean that in the first instance we have given our best shot at the actual electronic circuit design and totally dual-mono execution. These very circuits and layout techniques have been tested and proven in recording chains where price was of no consequence. Furthermore, we explain that the intent of the word 'Ultimate' is to allow the purchaser the choice of custom-specifying his requirements.

The board design of the **Ultimate** preamplifier has installation-ready options, which include a two-way crossover (at between 750 to 2500 Hz) for classic bi-amplifying; separate or "Quad" outputs intended for driving four amplifiers for surround-sound (alternatively, the extra buffer-stage may be used for isolating the RECORD output); as well as our innovative "Floating Symmetrical Mode" technology as an optional extra (approximately $700 and supplied with an XLR cable).

The **Ultimate**'s total dual-mono approach, with a fully-regulated and ultra-high capacity power supply positively does enhance imaging, staging and positioning of lateral information. Please note that we did not (and never will) fit two (highly inconvenient) separate volume controls; we feel this is unnecessary enslavement to dual-mono — after all, the 'marriage' is only by a mechanical shaft commonly rotating the 'wiper' on the actual resistive traces with certainly adequate separation to ensure zero channel-to-channel leakage at this point. Not so with the selector-switch, which is why we use one for each channel.

Experience with mixing-consoles has taught us that compact rotary selector-switches can leak within decks and deck-to-deck; larger ones are not available with sufficiently good contacts, being intended for higher current rather than higher signal-integrity purposes. Even so, we choose in the Ultimate to 'double-up' contacts, being over-conservative rather than allowing just one set of switch contacts to handle the signal alone. Again, with the 'balance-trim' control we felt that two separate controls were desirable. This was in the belief that, within minor adjustment limitations, the balance-control largely remains at or near a given setting.

Also, our method of controlling or trimming the channel-balance is somewhat different from commonly-used circuitry in that ours is based around a small variation in the feedback loop. This is because we do not like either the insertion-loss gain-wise of an additional volume control in the circuit nor its inherent deleterious effect on the signal path. If we can easily hear when a balance-control of the 'pre-fade' variety is switched in or out of a circuit then we feel it is not a permissible or desirable feature. Verily, we would like to omit any form of balance-control but realise that this is an essential control needed for certain recordings and sometimes for speaker position corrections (although we prefer not to think too deeply about this extreme usage of a balance control!)

Another important feature of the **Ultimate** is its anti-microphonic neoprene suspension of our non phase-inverting tubed MC step-up stage (also optional) and phono/RIAA circuit-board. Even the best tubes are not totally free of microphonic sensitivity and this is even more understandable when you realise that the maximum gain of the **Ultimate** can be set to some seventy-five-hundred-times amplification: *i.e.,* one and a half volts rms from point two of a millivolt or three-quarters of a volt form point one of a millivolt. Truthfully, this is stretching tube amplification technology to the absolute limit in noise terms, both from microphony and the Miller/rush effect.

If you will pardon a little digression from the subject at hand, may we tell you why we do not feel that a point 08 or point 1 millivolt cartridge is a good choice for any tube preamplifier? Quite frankly, we do not believe in the viability of a point 08 cartridge for any kind of active amplifying device. Can you contemplate the energy level emanating from such a cartridge at, say, 30 Hz with this frequency attenuated by roughly 18 dB in the RIAA procedure? There is just not enough excitation energy present to dredge music out of the grunge in any technology, except possibly with an expensively engineered step-up transformer from the same manufacturer, which is normally their recommended method of interface and which may exhibit a tendency to 'ring' besides requiring extraordinary location-positioning.

Yes, we realise that a miniscule-output 'coil of around point 08 mV can sound quite alluring to some; they can, like a sixteen-cylinder 500 c.c. engine, go very fast (but not for long, and then only with a team of grave-looking mechanics in constant attendance). This 'speed' is achieved or increased by the ultra-lightweight armature/cantilever assembly with possibly only about 50–60 turns on the armature, making the construction a little more possible rather than 'easy'.

Too, these units tend to vary greatly from specimen to specimen. With this type of cartridge it is all too easy to get into the position of "I love this cartridge for its smoothness but it needs so much damned amplification that its smoothness is lost in the amplification; therefore I need another amplification system." No. Sorry. What is needed is a cold beer and a hot(ter) cartridge, in our view.

When ordered with a MC step-up stage, the **Ultimate** is routinely shipped with the MC stage engaged (on) and set for a load of 400 ohms, which suits a large range of MC cartridges.

As to circuit topology of the **Ultimate**, two Class A triodes in cascade feed a cathode-follower output stage whose output coupling is via series capacitors at a very low impedance; the mid-point of these caps supplies the feedback return loop, which includes the frequency-selective RIAA circuitry and which returns to the first cathode via an impedance 'lock-down' circuit.

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The grounded grid MC stage (or Floating Symmetrical Mode stage in applicable models) precedes the regular 47 kΩ PHONO input and, as stated, all of this phono circuitry is located on the suspended PCB. The phono output is led to the selector-switch and on to the top, or high side, of the volume control, from which point the separate 'record' buffer stage is also driven. The volume control feeds into another cascaded Class A triode pair which drives the final output cathode follower, giving a very low impedance, lowered still further by the split-cap feedback method. The feedback loop contains the balance control, returning to the line-stage's first cathode. **N.B.:** the feedback loop can be modified to optimise a given cartridge/preamp/amplifier/speaker chain and, indeed, may well require to be so modified to suit other than a **VTL** interface. Please see circuit schematics in the appendices for further and more detailed information.

The Manley Reference Preamplifiers

The **Manley** Designer's Reference Series preamplifier, though it shares a fair amount of the **Ultimate**'s conceptual topology, has some outstanding and unique features:

1) All audio boards are on our specially-suspended anti-microphony mounts.

2) The switchover between MC and MM occurs on the front panel. This allows the use of two turntables if so required, or two arms on one turntable which would allow comparisons between two cartridges for review or analytical purposes. (Some people choose to use a moving-magnet for really old LP treasures — sometimes mono only.)

3) The Moving-Coil section, a separate board, is supplied only with our "Floating Symmetrical Mode" technology and entry is via XLR connectors only. Note: it is vitally important that the arm-wiring for the cartridge connection is connected correctly: red and white are the "high" sides and blue and green are the "low" sides; above all, these wires must not "see" the arm or turntable ground or chassis.

4) The unit has two power switches for its outboard power supply. Each switch is adjacent to and linked to its own two-colour LED indicator. The two colours indicate the power being switched over from "ever-on" (green) during warmup to "operate" (red) for full-power operation.

5) The moving-magnet or high-output 'coil' stage (which is also in-circuit when the moving-coil stage is in use) is a 'super-stage' paralleled double triode which has extraordinarily low levels of distortion due to its huge headroom margin — a circuit actually conceived for very high-output capacitor microphones in the recording chain.

6) A totally unique method of volume control found only in calibration instruments. For reasons of absolute sonic purity, the volume control itself is a rotary switch with steps of gradation marked 'coarse'. But because we know how infuriating it can be when one 'click' is just a tad too soft and the next a tad too loud, we have fitted a 'fine' vernier-type control *across* the volume switch, to make these precise settings possible.

By dint of this last innovation, you will realise that *at no time* does the audio signal travel only via a volume-control 'wiper-on-track' mode; the signal path is straight-through. Likewise, of course, the balance control is a parallel circuit to the feedback loop.

These features, combined with out proprietary "Floating Symmetrical Mode", bring a totally new horizon in the art of reproducing vynyl phonograph recordings.

The VTL Stereo Amplifiers

There are two stereo models (*i.e.*, both channels are on one chassis) in the **VTL** range. They share an identical circuit board and can easily be discussed together. The smaller of the two is the 45/45 (which replaced the 30/30) and it is built on our 'compact-sized' chassis. We re-designed it in June of 1989, and were able to "give more for less" — a strongly defended **VTL** trait. New features include a chromed chassis and "stiffer" dual power supplies of 500 microfarad capacity. The way in which we were able to offer more value was by the gaining of quantity orders for mail-order and export markets; we were able to pass this efficiency on to our customers. Old-fashioned, eh? We *like* old-fashioned values.

The stereo 90/90 (upgraded from our 75/75) offers 15 percent more power at the same price as the previous 75, and also sports a chrome chassis, of the larger **deLUXE** size, plus 1000 microfarads *per channel* in its power supply.

The 45/45 uses Russian military KT66's, while the 90/90 employs 6550A's as before. Both units are ultralinear in their output configuration: the 45/45 is set for only 5 ohms, while the 90/90 is factory set for 8 ohms (easily reset to 5 ohms by merely changing the green wire on the red or plus speaker terminal) for the green/yellow wire.

In their new livery, both of these models have their BIAS test points and corresponding pre-set trim-pots accessible from the top plate, thereby obviating the need to open the amplifiers' bottom cover to measure or set the bias. Bias is determined across 10 ohm cathode resistors which therefore require a DC millivolt *quiescent* reading of 300 mV for the 45/45 (corresponding to 30 milliamps standing current), and 350 mV for the 90/90 (corresponding to 35 milliamps standing current). Their input-driver configurations remain unchanged and are common to all our amplifiers under 120 Watts: both are 12AT7WA/6201's.

The VTL Compact Monoblock Amplifiers

These amplifiers are 80, 100, and 160 Watt units. Using a separate monoblock for each channel really does move one into the best league of stereo reproduction with demonstrable improvements in imaging and staging brought about by the separate chassis and ground paths. Also of course, a monoblock-based system offers a completely different setup plan than is commonly used for dual-channel units in that people like to place them very near the loudspeakers to take advantage of the short path in the speaker cabling. Please take due care and consideration of pets and toddlers when contemplating this kind of installation: it has become common-place to site the amplifiers right on the carpeted floor.

We don't recommend this for the pets and toddlers. In addition, a high-pile carpet will effectively close the vent-slots in the amplifiers' bottom cover, thereby restricting the upward air flow. It is better to position the amplifiers on a small stool or stand. If one has not got the pet and toddler factor to consider, it is advisable to put the amplifiers on a square of wood or particle-board to protect the carpet and allow air movement.

Our "compact" chassis is about one-third smaller than our larger deluxe chassis. We offer several power variants in the series. Constantly criticized for having too many models, we realised that 50 and 65 Watts *were* a little close to each other, and furthermore that higher power was most often wanted in a monoblock. Accordingly, we developed the 80 Watt monoblock with the price very close to that of our 65 Watt version. Yes, we will still build the 50 and 65 Watt versions upon 10-pair quantity orders, which is also the status of our 35 Watt triode monoblocks. Rather than being in standard day-to-day production, they are built in runs to suit export markets. We also added a 160 Watt monoblock to the cost-effective **Compact** series, built around the same common main board. The differences between these units are in the tube complement, the power supply capacity, and the output and power transformers.

The '80' has four Russian KT66 output tubes with a 6201 driver and a 6201 input, along with a 500 microfarad power supply and 5 or 8 ohm output impedance. The '100' has four EL34/6CA7 output tubes with a 6201 driver and a 6201 input, along with a 1000 microfarad power supply and an under-chassis adjustable output impedance. The '160' has four 6550A output tubes with a 12BH7 driver and a 6201 input, along with a 1000 microfarad power supply with a higher B-rail, and an under-chassis adjustable output impedance.

Yes, we realise that 80 Watts is very close to 100 Watts! The reason for both models, apart from their price, is similar to that of our 225 and 300 Watt monoblocks, the key being the wonderful EL34/6CA7 tube: people who love that tube will *not* settle for any other! This love of certain tube types occurs again with our807-powered 120 Watt unit: we respect that love, and will not deny the afficionados.

The biasing is by tube type: the 6550 runs at 35 milliamps standing current (350 mV from the test point to ground) while the KT66 and EL34 requires 30 milliamps (300 mV from the test point to ground).

The 100 and 160 Watt "compacts" have the series-parallel style output transformer with ABCDEFGH under-chassis tags while the 80 Watt version offers 8 ohms (green wire) as standard with a possible change-over to 5 ohms (green/yellow wire) under the chassis.

Please note that the output impedance is *not* a change we envisage to be performed by the buyer: a trip to the dealer is required. Only in rare cases is this change desirable in any event; the unit as shipped will drive all loudspeakers intelligently interfaced power-wise. For the record, the "rare cases" referred to above concern ribbon and other *known* difficult-to-drive loudspeakers which are actually better served by higher power.

The VTL deLUXE Monoblock Amplifiers

There are several models in this category: the 120, 150, 225, and 300 Watt units in the deluxe range, and the 150 and 350 Watt units in the **Manley** range. Let us discuss the '120' first.

The 120 watt unit is unique in that it can be (instantly) switched into pure Class A triode mode which yields 50 watts output instead of 120 watts in the AB1 tetrode mode. The unit employs four type 807 tubes in parallel push-pull. The 807's have their anode outputs in the form of top-mounted caps; we realise that this feature plus the triode-switching facility make the 120 a somewhat esoteric specialist amplifier and it is intended so. (However, the 120 is optionally available with 6L6GC's for those who feel that the anode-capped, romantic-looking 807's are just *too* esoteric! The 6L6GC and the 807 are closely related beam-power tubes with the 807 being closer yet to the British KT66; so close that the 807 was chosen by D.T.N. Williamson for the American version of his historic amplifier. But to our ears, the 807 has *no* equal in its triode configuration.)

Please note that the switchover to triode mode in the **120** must be made with the *power off* — it is *not* intended for zippo-like flipping. (But we know you'll try it; remember: the price of powered-flipover is greatly reduced tube life — don't say we didn't tell you!) The four triode/tetrode toggle-switches are located on the top front edge of the amplifier nominally in front of their respective tubes. With these four switches pointing *to* the tubes the amplifier is set TETRODE; switching them *away* (forward) from the tubes engages the TRIODE mode.

You might wish to hear the "Tri-Tet" mode also; this legitimate configuration operates with each half of the push-pull phase having a triode combined with a tetrode and produces about 75 watts output. In this mode the amplifier will stay in Class A up to about 25 watts; to select the "Tri-Tet" status the extreme right and left silver toggles must be left in the tetrode (facing rearward) position and the other two pulled to the triode, or forward-facing, position.

Now we come to the fifth switch, which is centrally-mounted in front of the (smaller) input triode. This switch allows you to decrease the negative feedback by 5 dB *which also* therefore increases the gain by a similar amount. The 5 dB feedback reduction position is with the central switch facing forward (same as "all triode" position) and is, we feel, of benefit only *in* the triode-mode; *i.e.*, with all switches engaged/pulled to front. Even so, you will need to be using an extremely accurate and low-distortion preamplifier because the amplifier will greatly magnify any traces of distortion. And, yes, you can leave the extra 5 dB of feedback (central switch pushed rearward) in the tetrode-position, if you prefer, with no harm done; in this set-up the liquid smoothness of the sound is very seductive.

Having read thus far, we feel sure you'll understand what we mean by the terms esoteric and specialist. Our prayer for the utilization of the **120** is that the audiophile who chooses it will know that he/she has ABC sensitive speakers which require (or only require) XYZ watts and will leave the amplifier set in one or other of its optimum modes; we hope that the switching facilities will not be used for party-tricks in tetrode-mode, with reduced feedback, driven to near-clip on Dire Straits.

There will be those people who will question the intelligence of making such an amplifier available at all. Well, the answer is to explain that as a specialist audio manufacturer we want to offer almost-historical products to the discerning audiophile (tubophile?) that advance both his/her knowledge and standard of musical-reproduction. It saddens us that there were audio products available thirty years ago that were actually better than some of today's ""breakthroughs" and moreso how few people know or remember or have heard this to be so.

You will note that on the **120** the protection-bar (please, not "handle") is mounted directly over the 807 anode-caps: this is intentionally done both to protect the tubes as well as to make the anode-caps a little difficult to remove. **Please remember that there is over 500 Volts present at these caps, and therefore they should not be touched with the amplifier on for fear of a dangerous electrical shock.** We recommend that the amplifiers be mounted out of reach. Better yet, we specifically do not recommend the **deLUXE 120** as the amplifiers of choice for a household which includes children and pets. It is a specialized unit designed for the informed and careful adult.

The design of all our amplifiers is such that the user should neither be constantly worrying about nor adjusting the bias voltages; it is only when contemplating the installation of a full set of new output tubes, which may be of a very different quality of manufacture, that the amplifier will need need to be fully re-biased. The biasing procedure *should only be attempted by trained personnel.*

The method of bias measurement, similar to that used in all our power amplifiers, differs only in that the the 5-pin 807 tube connections are totally dissimilar to the standard octal. (Pin 4 is the cathode for the 807; pins 1 and 8 for the octal-base in our equipment. The bias is set by measuring 260 mV DC at the cathode end of the cathode resistor and ground (or 0 volts). This converts to 26 mA of **DC** current being drawn in the quiescent state. Newer builds of the 120 have their bias test points along the front edge of the chassis, which is common to all **deLUXE** monoblocks. Other differences in the 120 are the 6 Volt DC rail for the heaters of all tubes, including especially the output 807's; DC on the heaters is mandatory to enable this mystical tube to perform its best.

The output transformer is set for 5,5 ohms, and we suggest and request that this be left so; the unit already has a two-position feedback switch (providing a 5 dB range) and, within the power constraints of the 807's particularly when in the triode position, no output impedance alteration is envisaged. As stated, this is somewhat of a specialist amplifier best suited to *very* efficient loudspeakers, commonly found in the triode-fans' systems — the JBL and other circa 100 dB types.

The **VTL** 150 Watt unti is very closely related in layout to the 120, and uses the same 1650 microfarad double-blank capacity network common to all **deLUXE** monoblocks, as well as the dedicated power supply (including a separate transformer) for the critical input tube. In the **Manley** version (cosmetics aside) which relate to front-panel access of bias-check and, importantly, the ability to select feedback in 2,5 dB steps and to optimise the feedback 'slope' capacitor for different loudspeakers. The 150 Watt units have four 6550A's as output tubes, and have multiple secondary output transformers (commonly set for 5 ohms).

The **VTL**225 and 300 watt **deLUXE** monoblocks are closely related to each other, differing only in their output tubes and transformer type. The 225 uses EL34/6CA7's, while the 300 watt uses 6550A's; both models use eight tubes per chassis. We used to consider the 225 a special-order unit but, as with the 120, there has been so much groundswell demand that we now routinely produce this model. Arthur Pfeffer of The Absolute Sound is very fond of his 225's, and the amplifier seems to be supremely suited to the excellent Martin Logan CLS electrostatics; again, it is the use of the EL34 that seems to be highly desirable to some folks.

The **VTL** 300 and 350 **Manley deLUXE** monoblocks continue to amaze us in their never-slacking rate of demand and back-order; we realise that this is due to their extraordinary sound, power, reliability relative to price ... easily able to withstand industrial use in control rooms, these big fellows run cool and just work, work, work.

In the **Manley** 350 watt version we offer the increase in power (which comes about via the additional dedicated supply for the driver and a slightly higher rail) plus the feedback and 'slope' variability as mentioned in the preceding 150 section. The output transformers are configured for 5 ohms and are of the multiple secondary type, easily reset to other impedances in an authorised workshop. The bias test points and adjustment set is accessible from the top of the units, as are the test points for measuring equal AC drive-input voltage to each of the push-pull output phases.

The 500 Watt and 1000 Watt Monoblocks

The 1000 watt **Manley** monoblock has recently joined the 500 watt **VTL** and **Manley** monoblocks. These power-houses are also dual-chassis (per channel) and are closesly related in topology to each other and the 300 watt units in that they are 6550A-powered and are fully ultra-linear. The 500 was clearly inspired by Harry Pearson, while the 1000 watt unit owes its 'birth' to the master cutting room.

The 'birth' of our **500 Watt Monoblock** has a human-interest (well, audio-human anyway) story that we feel is worth the telling. We were at the conceptual stage of design pre-thinking in power terms. We wondered whether there was a market desire for a 'super-power' tube amplifier (bearing especially in mind the large quasi-ribbon speakers), rather like the 1000 watt units we have custom-built for driving cutter-heads.

At precisely the same time, that master reviewer and standard-setting critic, Harry Pearson, was apparently pondering whether anybody else felt such a need existed, or whether anybody was interested enough and, indeed, capable of designing such a piece. In a phone conversation with Mr. Pearson's right-hand man, Frank Doris, the technical director of "The Absolute Sound", we voiced this musing of ours. After a perceptible silence, Frank said: "How extraordinary, for that is what HP has been contemplating exactly; I was going to bring that up next!"

And so the **'500'** came into being. As a matter of interest for those readers outside of the USA, can you see in the reporting of the above event how important Harry Pearson's constructive criticism and creative suggestions have been to the whole picture of High End audio? For he has steered many designers, besides ourselves, into radically improving or totally initiating worthwhile products. We thought you ought to know that we respect and are grateful for this kind of input enthusiasm.

Besides its huge 500 watt power, derived from two six-pack (hexagon) pairs of 6550's in push-pull parallel ultra-linear configuration, the immediately obvious difference between the **'500'** and any of our other **"deLUXE"** monoblocks is that the **'500'**, like the **Ichiban**, is built on two chasses per monoblock. The amplifier is built on one, and the power supply on the other. They are interlinked by a fat umbilical cord. Separating the power units from the amplifier has other important benefits apart from making them both 'workbench-negotiable' and easy to transport.

The idea goes all the way back to the early American McIntosh, Brooks and Western Electric units of the late thirties and forties; this is also how Mr. Williamson first presented his amplifier. It is Nth degree thinking; the desire for design without compromise. The EMI fields of magnetism do radiate to the tubes to some extent; more importantly, the minute vibrations mechanically generated by large transformers (and we're talking 2 kVA here) do permeate to some extent, no matter how well they're built.

Further, like the **Ichiban**, the **'500'** has on its separate power unit dedicated supplies for the full input circuitry, thereby leaving the main monster power transformer to cater for the output stage's needs exclusively. The other significant difference is in the driver-stage, wherein paralleled 12BH7 triodes each drive half the push-pull phase; that's live watts of audio power driving of each side of the output section, by the way.

Because of the number of output tubes in the **'500'**, we have made bias-measuring easily accessible with standard resistor colour-coded 'tip-jacks' appearing in front of the tubes; as with other models the bias is not worrisome, and is set for a cool-running 30 milliamps quiescent current.

The Ichiban Pure Class A Triode Monoblocks

What? Why? Who? When? Where? are the usual preceding words to questions about this inscrutable unit of ours. First, 'what' it means (in Japanese) is "Number One". We refer to that in the sense of importance, for it is the (now) antique triode that set, and still sets, the the historical and current standard of audio amplifier excellence. In simple language, triodes will always blow any other form of amplifier far, far away (within their power capability, obviously). And thereby comes that efficiency thing again, for triodes certainly are outstandingly inefficient. In pure Class A this is even moreso, where efficiency is deemed to include heat, size, weight and cost. Besides the triodes' need for high anode voltage (for reasonable power) and high current for their filaments/heaters, they have very little gain or amplification-factor (as low as 2 ×) and are notoriously hard to drive. Commonly, in bygone times, they needed inter-stage transformers to help overcome this problem. In 'triode-mania' territories the use of a tetrode strapped as a triode is termed 'pseudo-triode', but we don't agree this should be applied to the EL34 for the reason that a very select number of tube types, and the EL34 is such an example, were specifically designed with triode-configuration strongly in mind — the 807 is another, by the way.

The double-chassis **VTL** and **Manley** versions of the **Ichiban** both are supplied with rare South American redwood side-members. The **Manley** version has large milled panels which house the variable feedback and slope controls, and bias testing facilities. Other than that, *there are no differences* between the **VTL** and **Manley** versions; this is because the **Ichiban**, like the 500 and 1000 watt units, inherently have dedicated split power supplies for input and driver stages. We use two Class A paralleled resistance-coupled triodes (what else!) sections in the **Ichiban** and in most other respects it is similar in topology to the **'500'** described elsewhere. In its standardly-delivered build, the **Ichiban** utilises twelve

EL34/6CA7's configured in triode mode. Its 200 watts of output power make it the world's most powerful Class A amplifier in standard production. The **Ichiban** is another case of something we thought might be only of interest to a select group that turned out to be popular enough to warrant keeping it in standard production — though with some lead-time which we are constantly trying to reduce.

Elsewhere you have read our views on what smaller triode amplifiers can do for music; we leave it to your imagination what *this* size of Class A triodes can do — modesty precludes our repeating all comments from **Ichiban** owners. Here is just one portion of a letter from a very discerning musicologist/owner, Herman Ng:

> The most arresting impression from these triode amplifiers was their ability to reproduce the natural tonal qualities of the musical instruments, as well as the harmonic decay within the particular hall regardless of the playback volume. This goes for solo instruments, as well as the harmonic decay within the particular hall as well as full comples symphonic music. Because of the faithful reproduction (tonal and harmonically accurate frequency response) the illusionary sound curtain is so real that it borders on the *un*real.

Thank you, Mr. Ng; we could not have put it better ourselves.

The people who will settle for triodes only, (this is the 'where' and 'why' part) are a select band of audiophiles who use very efficient loudspeakers (a necessary counter-balance) and are found in the woodwork of Europe and Japan. Eschewing sub-woofers and megabuck-megaspeakers, they 'trip' on triodes, often as low as four and five watts worth, and will brook no argument about their preference. The **Ichiban** with its 200 watts assumes the output status of broadcasting and power-stations to them. Are they wrong in their audio thinking? No, not at all. Nobody is wrong in their desire to listen to their studied preferences, in our view. If we played you some Klipschorns being driven by gossamer-smooth triode amplifiers, you would probably be very agreeably surprised. Shaken, maybe. You might even want to own some.

You don't believe this is possible? Your favourite audio-dealer does not keep Klipschorns? We knew that. You find it very hard to swallow that older technology can be good technology? Possibly even better technology? Don't bet big on it. Doug Sax and Lincoln Mayorga of Sheffield Recordings went through the same painstaking process of sifting through older equipment and methods that had been steam-rollered by the great big truck sign-written *'NEW!'* and rediscovered how to make good records again. **VTL** equipment uses a large measure of well-proven older technology, updated with current componentry and by giving attention to little details that seemed of minor importance thirty and forty years ago.

A great portion of the answer to these enigmatic questions lies in trends and fashion, as also found in other fields of endeavour. When the (then) new, smaller (and awful-sounding) solid-state amplifiers first appeared in the stores thirty-five and forty years ago, accompanied by shrieks of *'new'* and *'breakthrough'*, a new kind of thinking began.

In terms of size, ("smaller is newer, better") and sound ("ever so clear and deep") became the herd-generated cry. Storekeepers have got to keep what their customers want, or they soon become ex-storekeepers. Klipschorns do not produce a good sound when driven by garbage and, too, they are big. Exit Klipschorns from the trendy stores. Tubes glowed red, got warm and were plugged-in! Exit tubes; exit especially triodes. The rest, as they say, belongs to the rich tapestry of history.

What digression? So the passion for triodes lives on, and particularly for the grand-master 211 and 845 types as used in one version of the **Ichiban**. These tubes are heinously expensive ($150 to $250 each) because like the 300B they are near-collector's pieces in their own right. But (we noticed you shaking your head and leaving just then) they can last a quarter and maybe half a century! (Ah good, you're back.) Offering the triode-switchover possibility in our 120 watt unit arose out of a desire to give audiophiles an opportunity to listen to triodes at a sane price while still retaining the option to have the 120 watts of power at hand. We will still build the 845 version, which produces only 100 watts, to special order but in all honesty the 200 watt standard-production version simply blows it away.

Who knows? We may just cause a re-awakening. Besides, we really enjoy building all our equipment and the more particular the buyer, the keener we find the challenge.

General Reliability of High End Equipment

Quite rightly, this topic is raised very often in the hi-fi journals. Responsible manufacturers, and we count ourselves so, *have* to be highly concerned about it... and to keep this factor in the forefront of ongoing research. However, we believe that some clarification is in order to lend some perspective. Unreliability generally falls under these categories:

1) Design shortcomings: totally unforgivable.

2) Individual component or part failure of *correctly chosen* pieces.

3) Latent assembly failure: the soldering/wiring connection of the internal parts.

4) User abuse or wrongly-chosen interface.

5) Incorrect installation/diagnosis: the 'suspect unit' may not be faulty at all within itself.

6) Failure caused directly or indirectly by shipping damage or mishandling.

That's quite a list of possibilities for a manufacturer to guard against! Clearly he is totally responsible for faults designed into the equipment (1 above), and also for faulty assembly in his plant (3 above) — but bear in mind one is dealing with human beings, not robots!

In the case of individual part failure (2 above), all a manufacturer can do is to seek the best components from reliable sources (we do so regardless of cost) and to switch away from suppliers whose parts start to reveal a 'tendency trail'. The three other headings are really out of his control, with the limited exception of reducing the chances of shipping damage (6 above) by the quality of his packing crates. We go overboard here, regardless of cost; by packing our equipment in deep, firm foam and a heavy-duty box within a box technique — to the extent that the two major US domestic shippers have independently declared "If it gets damaged in this packing, it will not be your fault!" (They've also told us to stop putting 'fragile' stickers on "...because conveyors and drop-loading machines don't read so good.")

The press, and we *do* admire their watch-dogging on customers' behalf, sometimes imply that at high end prices, there should be no failure ever, for any reason. While striving for that very goal, we have to say it's not completely feasible — breakdowns can and do occur in astronomically-priced aircraft, NASA-projects, exotic automobiles (there is a special parallel here) and the cause will almost always end up as being due to the 'human factor': the parallel is that these areas of endeavour, like high end audio, are built in somewhat limited quantity *by hand* — and there's the rub. It is not as though we're talking 'cottage industry' here, but many items built in the 'hot shop' or cutting-edge-of-design establishments cannot ever, demand-wise, be put into continuous production.

Here is an interesting little analogy to run over in your mind: You know how satisfying it is when a motor car serves you reasonably well for 100,000 miles? How fond of and grateful you are to it and its designers and makers? How you tend to forgive and forget all but disasterous expenses in keeping the car on the road up to that point? Well, if the car spent its running life at an average speed of 33 miles per hour, it would take just three thousand hours of operation to clock up 100,000 miles. Audio equipment in constant use can easily see three thousand hours in one year!

Please do not read into these thoughts any complacency on our part. On the contrary, we urge the press to "tell it like it is," trusting of course that they will have their facts crystal clear and accurate in the reporting. We feel that sometimes they err on the side of kindness; probably because they are aware of the limited production and market factor: we know of cases where certain brands, let alone a particular model, *don't make it through the review period* (on one sample, we mean) and these details get buried.

Returning to the possibility of unprovoked failure, we point out that we are somewhat unique in our standards in that we *want* you to get truly lasting value and pleasure from our products. Our lifetime warranty shows our commitment to this goal, and underscores the confidence we have in our designs and their manufacture. Our willingness to have our equipment in professional studios to further prove and improve our reliability should tell you a lot too.

One last thing, of which we're very proud, is that in the unlikely event of breakdown our equipment is designed with serviceability in mind: it *can* be worked on efficiently by any competent serviceman; we make our schematics available and most components are easy to get. . .we supply free issue of purpose-designed and manufactured major components to distributors and authorised repair centres under our warranty terms. Could we do more?

WARRANTY

All Vacuum Tube Logic equipment carries a transferable lifetime warranty. This covers all components and workmanship, but does not include the tubes. In the case of **VTL** power amplifiers when driven only by one of our **VTL** preamplifiers, we offer a six-month warranty on the tubes. All preamplifier tubes carry a six-month warranty. We go to extraordinary lengths and expense to procure and fit only premium-quality tubes, from which we expect (and commonly receive) thousands of hours of life.

We must point out clearly here that there are certain conditions attached to our general warranty:

(1) that the equipment be supplied by the dealer at or near our recommended retail price, and that the purchaser retain a copy of the sales transaction, which can be produced for us upon request. (Yes, *yes,* we do understand commerce well enough to realise that a purchaser may be granted some discount when making a large cash purchase, and/or that a part-exchange may form a portion of the payment.) If you are reading this manual after having beaten your dealer into the ground for a large discount, you might want to read this and the next paragraph through slowly a couple of times. This is because the dealer plays an essential part in the relationship between you, the audiophile, and us, the manufacturers, both in the correct supply of the equipment and in its after-sale service. We believe the professional audio dealer really earns his money in customer satisfaction and deserves his legitimate mark-up for helping the customer to make up his audio system.

(2) we expect the supplying dealer to stand with us and the purchaser in looking after minor problems in the dealer's own workshop: problems that are easy to fix at a cost far less than shipping charges to and from our factory in California. We refer here to things such as the replacement of diodes, resistors and small capacitors. We will supply these and any other parts needed free of charge.

(2A) THIS IS WHY WE INSIST THAT UNITS SENT TO US FOR REPAIR (BECAUSE IT WAS OUT OF THE DEALER'S SCOPE OR ABILITY TO EFFECT REPAIR) ARE NONETHELESS RETURNED TO US BY THE DEALER; PREFERABLY THE ONE FROM WHOM THE UNIT WAS ORIGINALLY PURCHASED. IF YOU HAVE MOVED OR THE DEALER IS NO LONGER IN BUSINESS OR MOVED, CONTACT US FIRST FOR A RETURN AUTHORIZATION.

(3) in order to give effect to the transferable warranty, we require that we be advised in writing when a piece of equipment passes second-hand to a new

owner. A postcard stating type, serial number and previous owner's name is all we need to update a component's history file.

(4) that no modifications of any kind have been carried out without written factory approval. Any unauthorised modifications found in equipment returned for warranty repairs will be restored to original specification at the owner's expense before the supposedly required repair is commenced. Furthermore, if we are convinced that the modification in any way contributed to the equipment's failure, then the entire service charge and the shipping costs will be billed to the customer. Experiments with different tube type-numbers are deemed to be unauthorised modifications.

(5) that the equipment be used for its intended purpose: the reproduction of music in the home. (We do design and build custom equipment for recording studios, discotheques and delightfully deranged but famous musicians: but we like to know who, where and why in advance.)

Yes, we have heard the clever question, "whose lifetime?" Well, we realise that nobody lives forever; people, and corporations, pass on. Ours is a family business, and Luke is under 30... we have no intention of selling out, but even if that did come to pass our guarantee obligations would be line one, page one.

What we are offering really is a gentleman's agreement: *you* treat your equipment with due care and *we'll* make sure you don't have any maintenance costs (other than tubes) — it is a fact that we do not own any stationary printed "Workshop Repair Invoice." Please, though, make only *authorised returns;* see 2A above.

Other than these caveats, we are proud — extremely so — of having sufficient faith in our designs and their hand-worked execution to be able to offer our unique lifetime warranty.

Analogue and Digital: Big Discs and Little Discs

"What to do? What to do? The outlook is decidedly blue..." Have you seen the slogan on T-shirts that says "Digital finishes what the transistor started"? No doubt about it, we concur with at least part of that heartfelt cry. But we feel there is, has to be, some hope for digital recording. Indeed, we have proven it to ourselves by simultaneously recording an orchestra direct-to-disc, on analogue tape and digital tape, with appropriately different microphones and placement, but using *tubes only* in the audio-chain.

At the risk of jeopardising some friendships, let us list some of the most controversial points (some of them distressing) and not in order of importance:

A) Digital recording and Compact Discs with their under-provided sampling rate are here to stay.

B) CD has been introduced and targetted for, obviously, the mass-market: the lowest common denominator in quality terms... so what else is new?

C) The most painful shortcomings of digital recording are the serious deformations of low-level signals (subtle details, finesse) and which therefore also damages acoustic signatures by poorly capturing *temporal* information to which the ear is highly and accurately sensitive.

D) Some pop artistes (mainly vocalists) find that the newest Dolby SR is so good (noisewise) that the best EQ 'sweetening' is still to be done in the analogue domain!

E) *However,* let us remember that most (80, 85, 90 percent?) of recorded music sold is of the 'pop' genre (the common denominator at work); and in pop recording (mainly multi-mike, multi-track and multi-dollar) all the 'action' takes place in the top five dB of the level-metre... *okay, ten* dB for the really subtle stuff.

F) A recent (April 1988) symposium of musicologists in France opined that digitalia and CD are good, very good for piano and pipe-organ repertoire.

G) In the world of classical music, very little 'name-artiste' material is being recorded in analogue now or has been in the past five years. The smaller, quality analogue record labels simply will not get Messrs. Ashkenazy, Bernstein, Pavarotti and Co. near their microphones.

H) This caliber of artistes seems to like, nay insist on, digital recording. Herbert von Karajan has openly stated that analogue recording is 'gaslight': do not be tempted to think that a man of this experience and integrity can be 'bought' in soap commercial context.

I) All the smaller, quality-conscious analogue labels release their excellent work on CD (the biggest in this select group tell us they couldn't survive otherwise). In some cases the end result is truly pleasing, such as Peter McGrath's fine engineering on Harmonia Mundi.

J) In acoustic recording (recorded all at once) it *is* possible to improve CD's hall sound by exaggerating it somewhat: *e.g.*, on the Chesky Jazz releases.

K) Very occasionally a digitally recorded master turns out somewhat better in its analogue transfer to LP vinyl: this would seem to demonstrate that the master-tape had some merit.

L) CDs' superior noise-levels and dynamic range, pitch constancy, longer playing time and ease of handling *are* desirable attributes.

M) CD seems to have allowed a fair amount of neglected repertoire and new artistes to become available.

N) Re-releasing treasures like Reiner on analogue with improved mastering and pressing is commendable; yet the CD versions outsell the vinyl.

O) The record companies are pressing fewer and fewer LP discs; they really don't *want* to press vinyl. Clearly,the vinyl pressings in recent years reflects this when compared with 'best effort' pressings of a decade or so ago.

P) Older LP's are getting harder to find; even used gems can be very expensive. The more we mention scarcity, the higher the prices will go.

Q) No doubt, the best-sounding analogue is simply the best music you can hear through your system.

R) That said, LP's do have some inherent disadvantages endemic to their basic technology, which after all was never envisaged as being capable of withstanding the sophisticated information-retrieval accuracy offered by today's 'killer' turntables. The mass-production vinyl pressing is somewhat akin to newsprint-quality paper: the finest colour original simply will not print very well on it. Problems of pitch-variation caused by eccentricity and other mechanical aberrations; inconsistent sound-quality from beginning to end of side due to diameter-reduction (travel speed) of the groove; and (dare we say it) surface-noise.

S) The premium quality cartridges, turntables and arms are costly pieces of art (requiring extremely careful handling; a tiny 'oops' can cost a grand and ruin your day!) These premium 'front-ends' are the standard of reference used when attesting the superiority of analogue vinyl, whereas the CD reproduction is compared on a player often costing less than the reference cartridge alone.

T) An LP with disturbing "ticken-poppen" surely dampens one's musical ardour; mistracking or groove-skipping can collapse it altogether.

U) Nobody can say that they *like* changing and cleaning sides mid-movement, mid-Mahler.

V) CD's arrival definitely has added new impetus to the home-audio hobby and the music industry.

W) New "Killer" turntables often engineered (and costing) up to and beyond mastering-lathe quality keep appearing on the audio market: are they destined to play only extant record collections? This would be like producing new automobiles by the thousand in the vain hope that sufficient new and used tyres already exist to meet and satisfy all needs.

Does listing these pro's and con's give us the appearance of a defense-lawyer acting for the condemned CD? Please do not misconstrue this; one must constructively assess the state of recorded music available in today's audio world and try, if possible, to improve it.

Reprise: What to do?

Four possible approaches spring to mind:

1) Institute a scheme to ensure that *all* the best, even if dated, analogue catalogue remains available on premium vinyl pressings. We have the plan, method, contacts, and background to do this but not the funds or advertising/distribution medium.

2) Significantly improve CD players by over-sampling, but this won't solve the low 44.1 kHz sampling-rate birth defect.

3) Seek an entirely new storage medium: A VHS or Beta videocassette with two beefy tracks running at 10/12 inches per second? Count on zero interest from the major record companies; they deeply (financially) believe CD is the final solution.

4) Wait and see, but don't expect miracles! Playing CD through tubes in the meantime helps greatly, due to the tubes' linear characteristics with low frequency and harmonic distortion.

However, the aforegoing ideas are not implementable by the music-loving audiophile. What should he/she do about it? We don't see that one has any choice *but* to include a CD player in the system as an alternate source. For sure, there is material being released only on CD that one wants (sob! make that *needs*!) which is why we offer a sanely-priced **VTL** tube-upgraded Magnavox unit — very , very listenable and used daily by us, we assure you.

Our buddy, Mike Moffat of Theta fame, as well as a leading British firm and a couple of the japanese majors offer an "outboard Black Box" approach, wherein the (pure?) digital data stream is tapped at or near the laser-scanner, thereby relegating the player itself to almost turntable-like status. 'Trade-buzz' has it that a couple of the mechanical wizards are at work on Super-Duper-*nth*-Degree CD mechanical movements and major improvements in the D to A and A to D converters are emerging all the time from specialists like Burr-Brown. Our new Floating Symmetrical Mode for moving-coil cartridges puts even greater distance between CD and vynyl, but it certainly will have *zero* effect on the availability of vynyl albums! Treasuring your LP collection and supporting new analogue releases is really all you can do to ensure that your children get some sort of chance to hear the best of analogue recording.

IN CLOSING

We would feel most sad if the reader were to feel that the prime purpose of this book was simply to promote tubes and older techniques whilst 'bashing' transistor technology as a whole and the men of great vision involved in the field. These people exhibit indomitable faith and endless patience (but with seemingly acrobatic hearing). They are steadfastly endeavouring to make these clever little devices (switches? current-limiting amplifiers? chips?) produce music in the Stradivarius-Bosendorfer-Ruffati league. We *do* wish them well and *do* admire their tenacity and faith.

Furthermore, the world of audio owes them a great, but not obviously-perceived, debt: for in their reaching, delving, hoping and searching endeavours in pursuit of the 'Holy Grail', they have uncovered (and often re-discovered) some really fine adjacent or complementary concepts, many times causing them to become standard practice. These include concepts such as better cable technology, high capacity power reservoirs and moving-coil cartridges to name only a few examples. However, when presented to the public as "the missing link", we find we cannot always agree. Sadly, some of the missing technological links vital to musically accurate recording and playback seem beyond the understanding and reach of solid-state science.

A

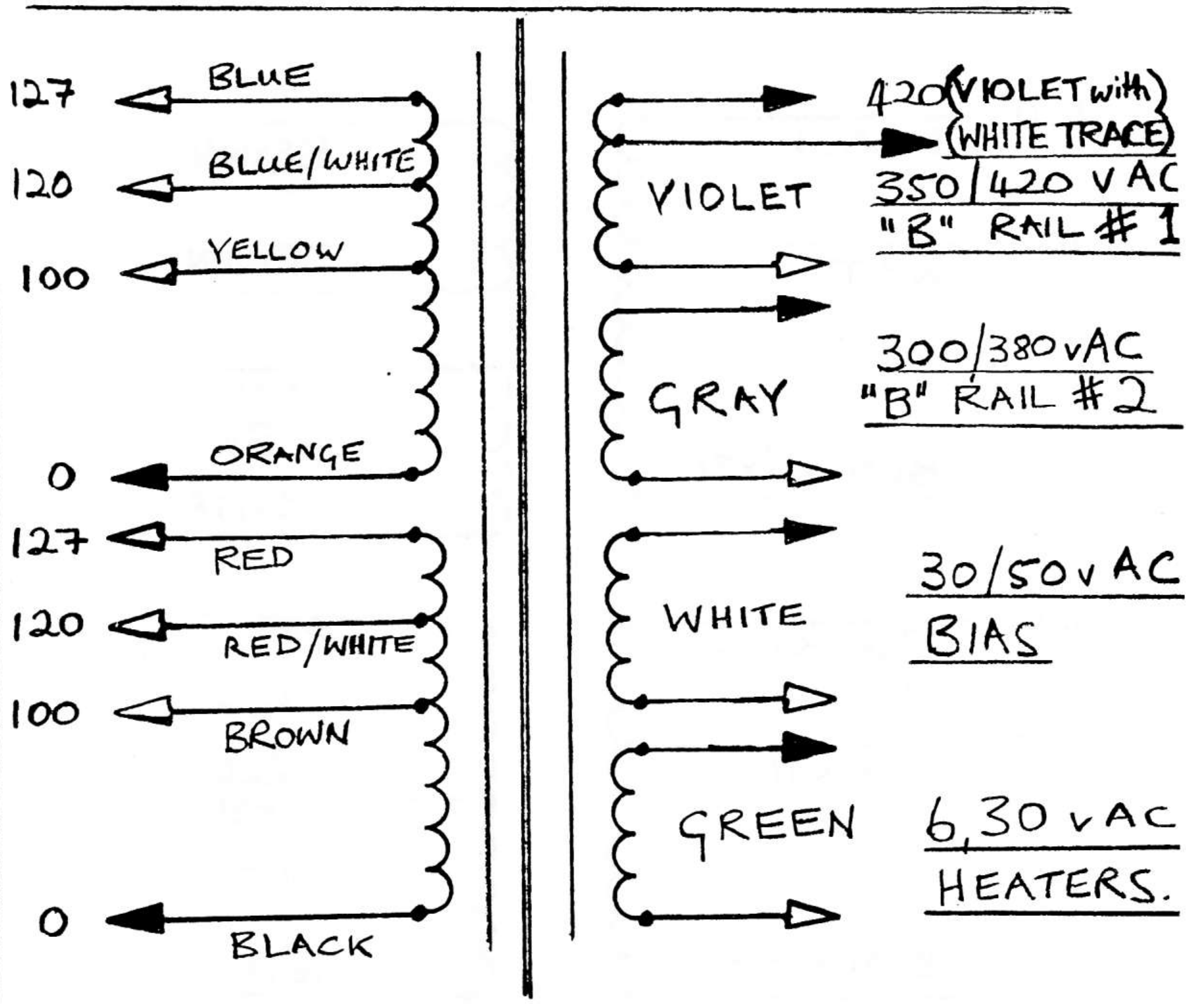
VTL

AMPLIFIER POWER TRANSFORMERS / COLORS

TYPE VTP 175 in 100, 75 and 160 models

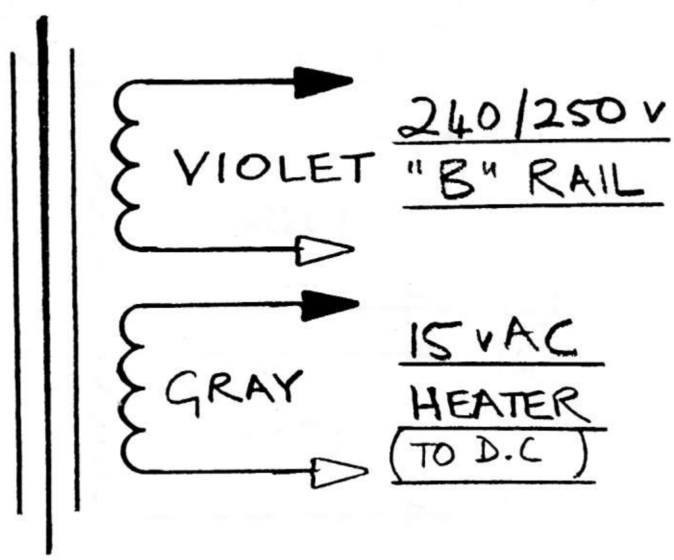
TYPE VTP 300 in 225 and 300 models

TYPE VTP 500 in 500 model; also VTP50



VT-102 PWR. TRANSF. (PREAMPS and CD mods)

PRIMARIES AS ABOVE

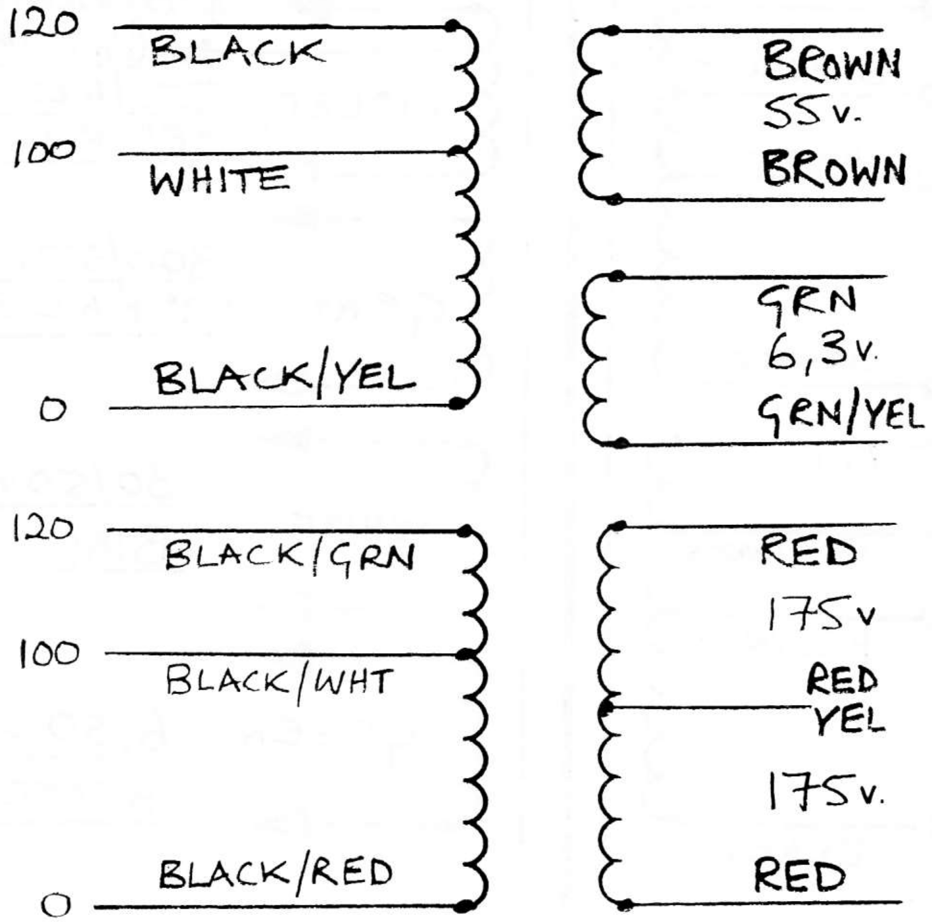


B

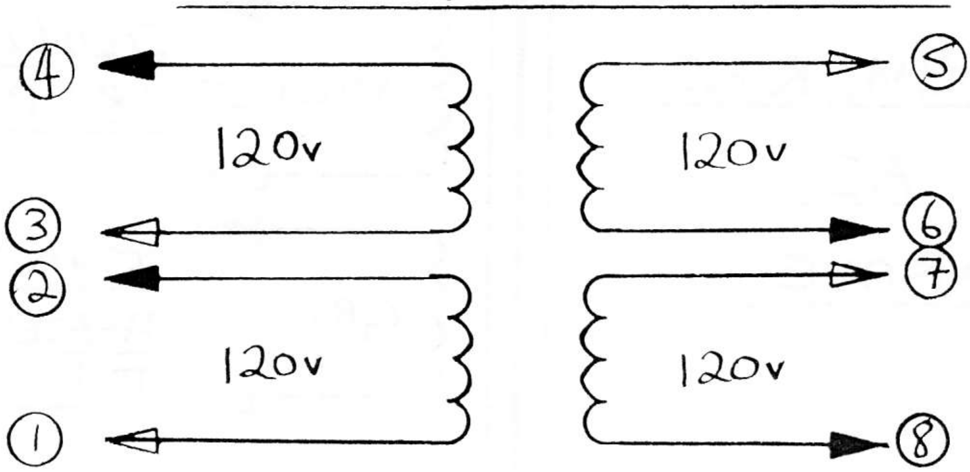
VTL

AMPLIFIER POWER TRANSFORMER / COLOR CODES

TYPE VT-TF in TRIODE - MODELS ONLY; 50 watts, 120 watts and "ICHIBAN"



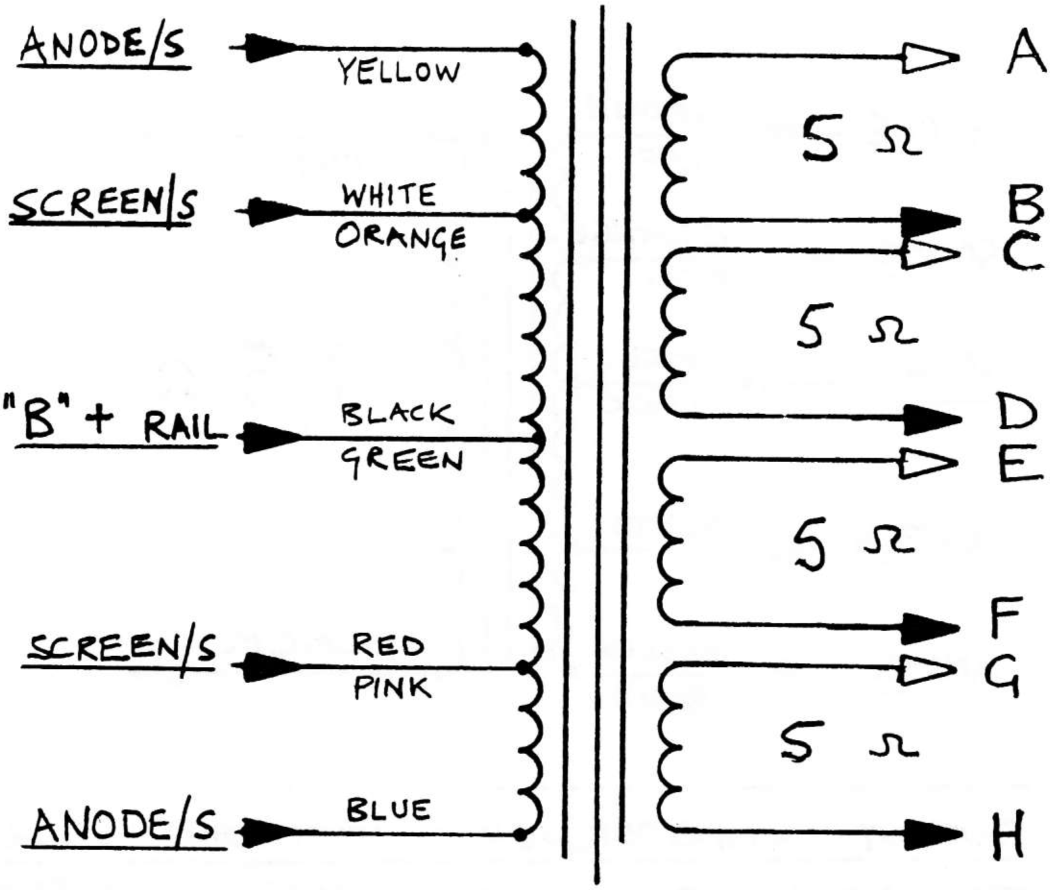
"SIGNAL" type 230/50 - AUXILIARY SUPPLY in 120, 225, and 160, 300 models



© VTL

OUTPUT TRANSFORMER : (MULTI-SECONDARY)

as in all models 100 watts UPWARDS



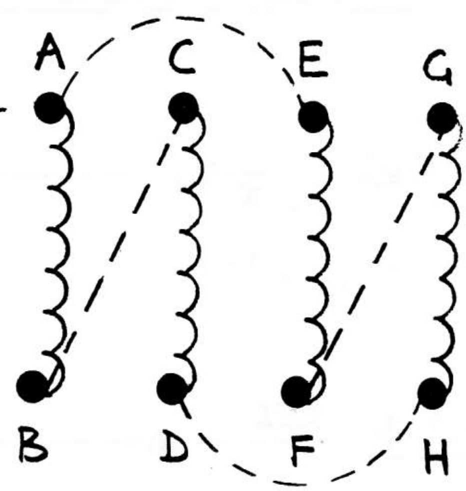
* **5 Ω (STANDARDLY SHIPPED)**

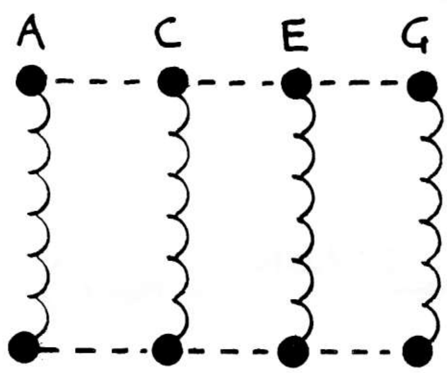
series-parallel ; RIGHT →

1,25 Ω all-parallel ; BELOW.

OTHER OUTPUT TERMINATIONS SET AT FACTORY

ONLY



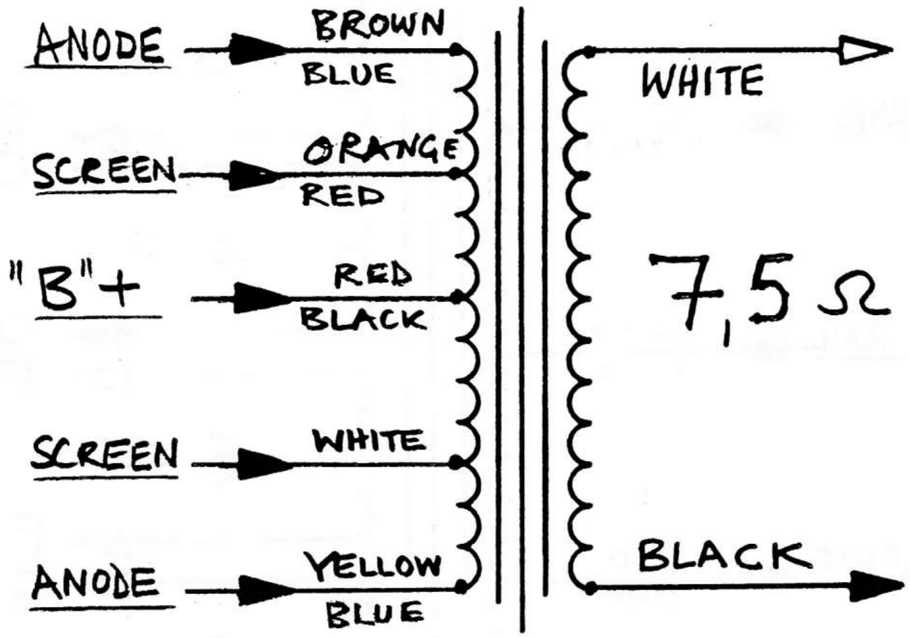


FEEDBACK R + C

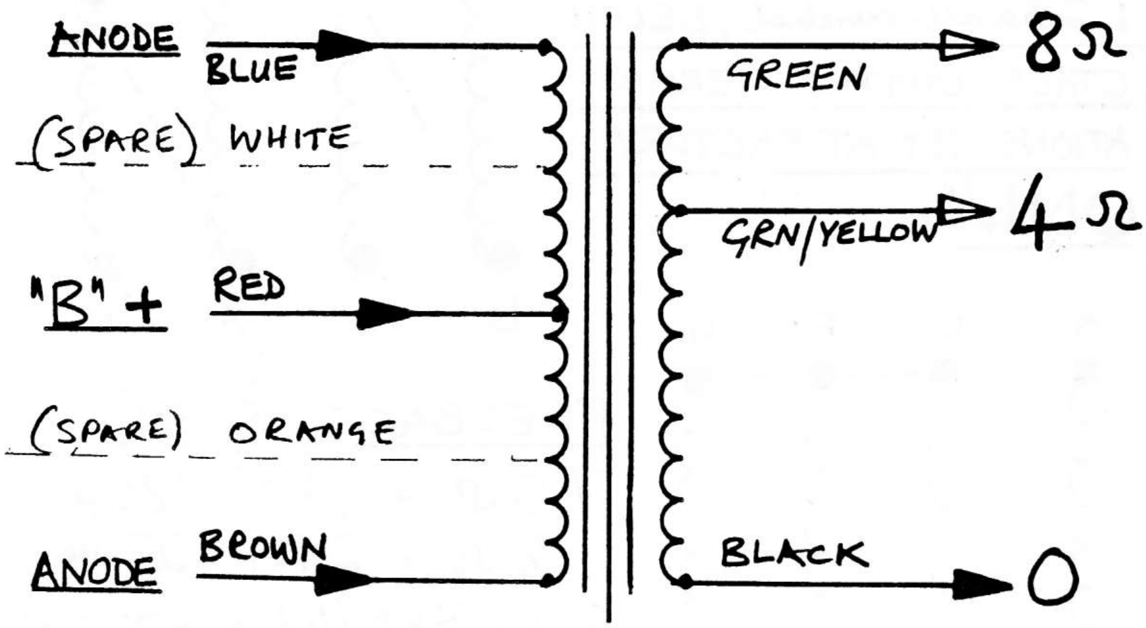
7,5 Ω = 4K7 + 180pf
1,8 Ω = 2K7 + 270pf
5 Ω = 3K9/4K3 + 220pf
1,25 Ω = 2K2 + 330pf

* 5 Ω standardly shipped from OCT 88 onwards.

OUTPUT TRANSFORMER : ULTRA-LINEAR, FIXED SECONDARY as in 50, 60 + 75 watts



OUTPUT TRANSFORMER : TETRODE and TRIODE MODELS ONLY, 45/45 and T35M

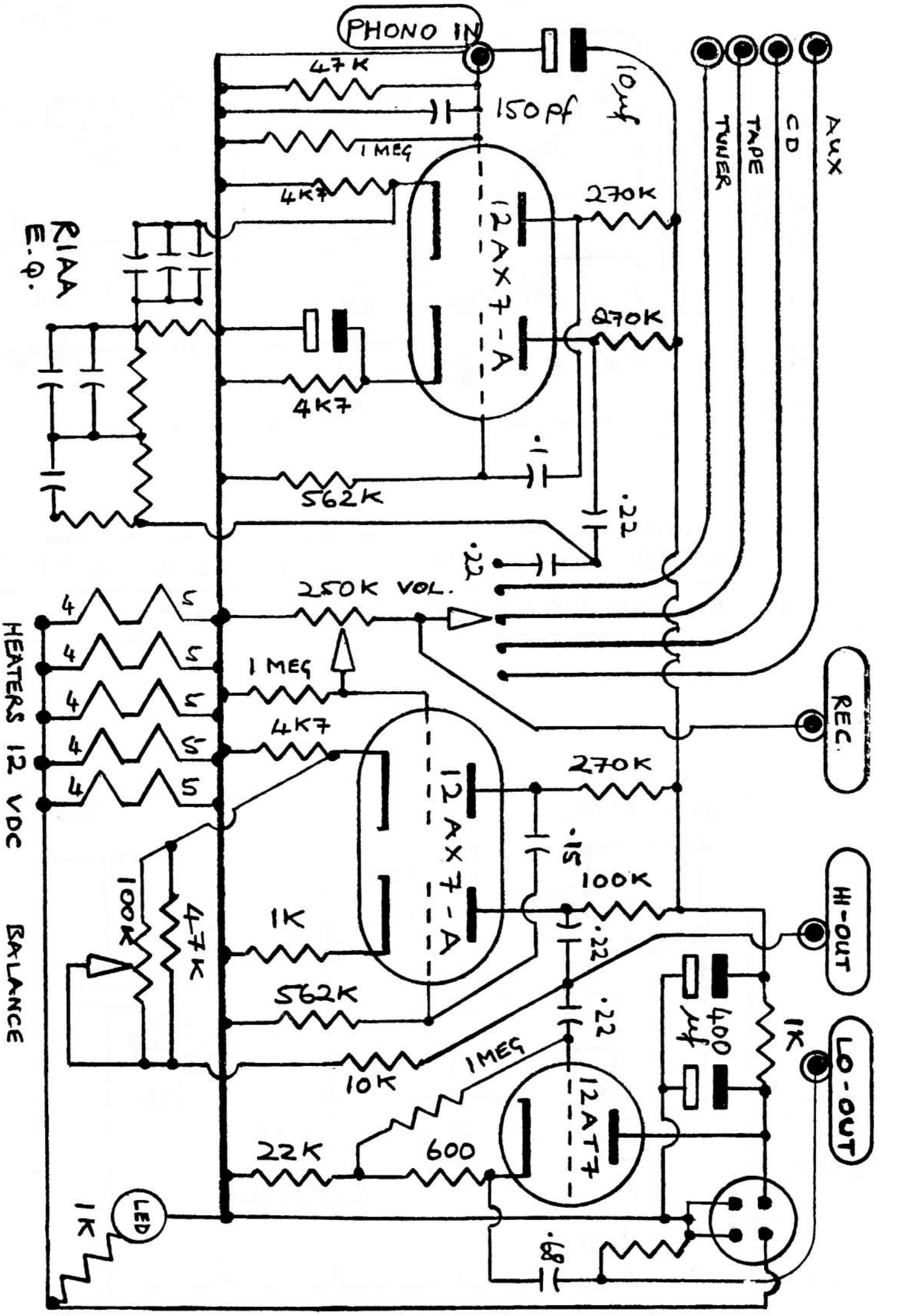


E

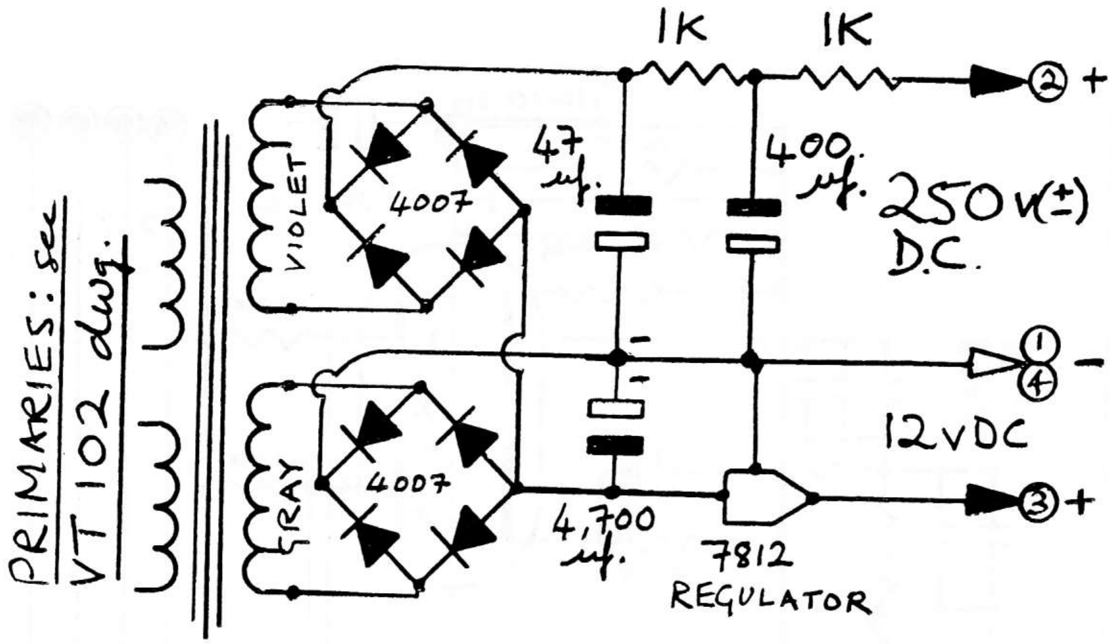
VTL

"de LUXE" PREAMPLIFIER – AUDIO SECTION

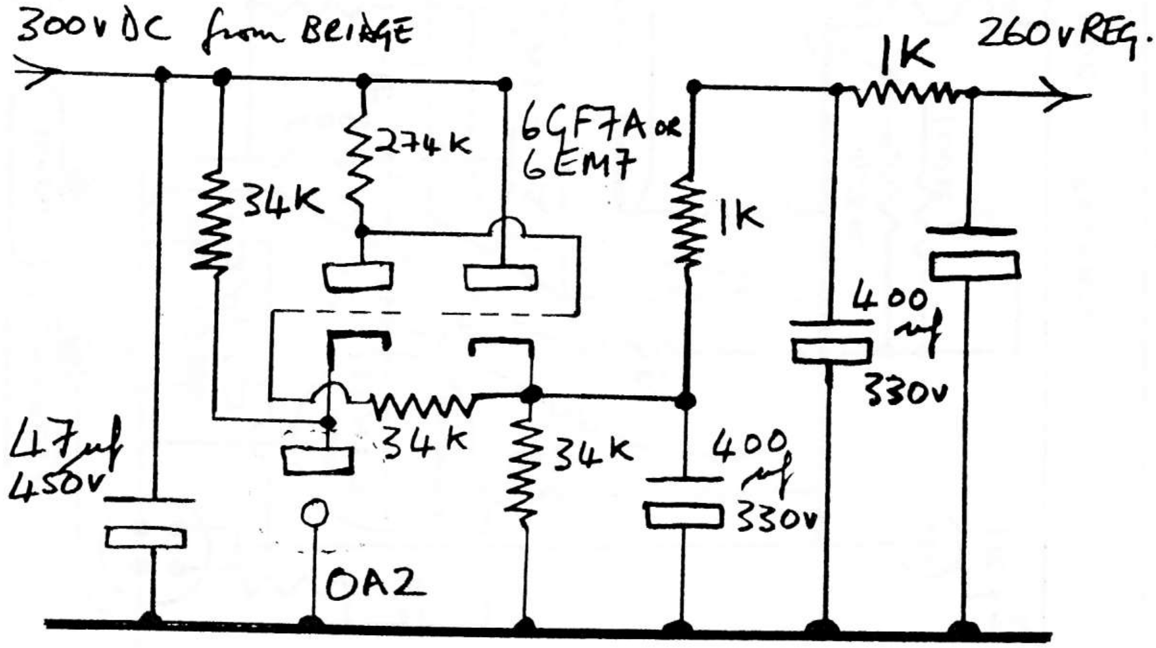
ONLY ONE CHANNEL SHOWN



PI-FILTER SUPPLY – de LUXE and SUPER de LUXE PREAMPLIFIERS



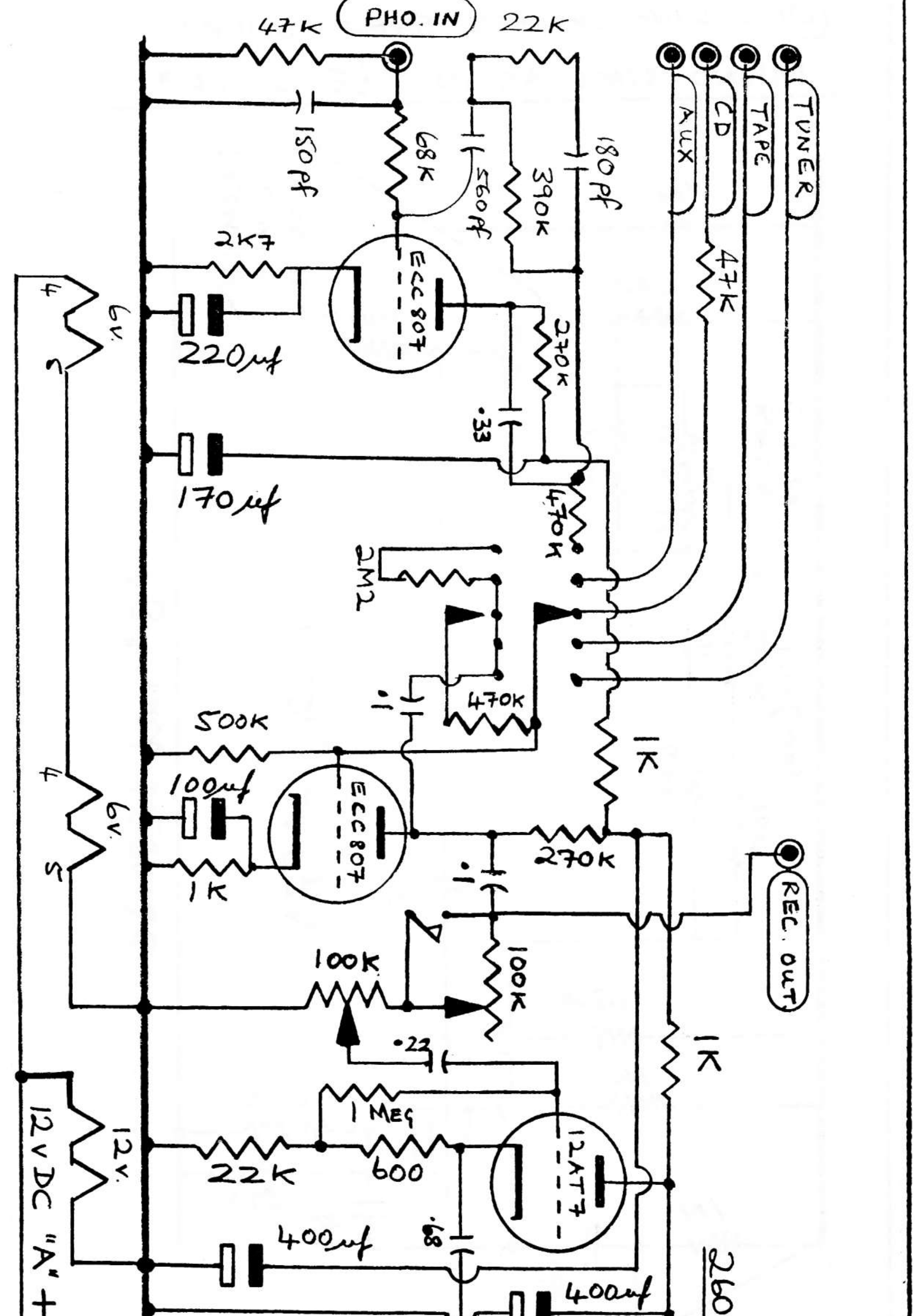
REGULATED "B" SUPPLY (±15% LINE SHIFT) UTILIZED IN MANLEY EQUIPMENT.



VTL

ONE CHANNEL ONLY

"MINIMAL" PREAMPLIFIER — AUDIO SECTION

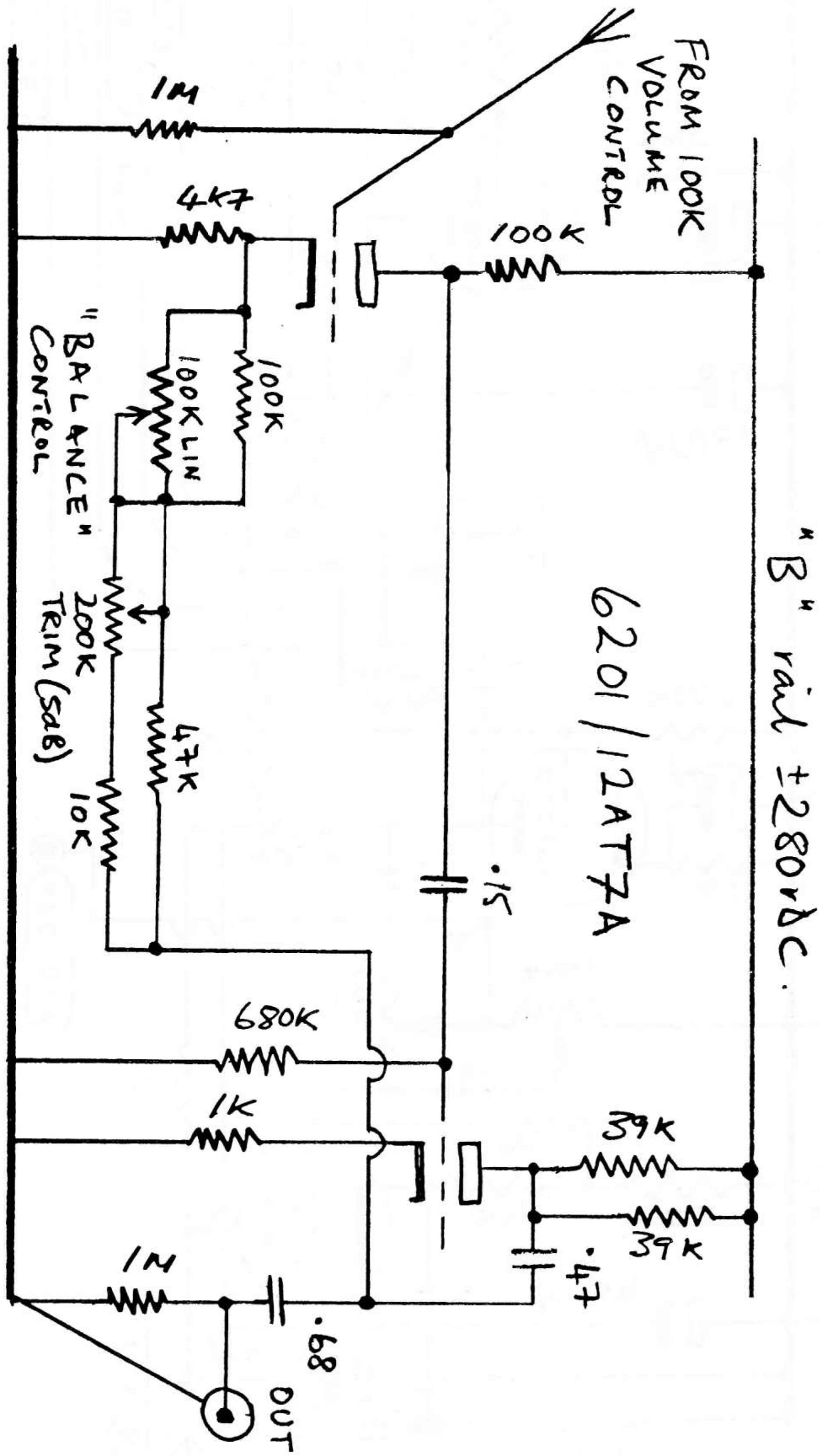


VTL

"MAXIMAL" PRE-AMPLIFIER

(ONE LINE-CHANNEL SHOWN ONLY)

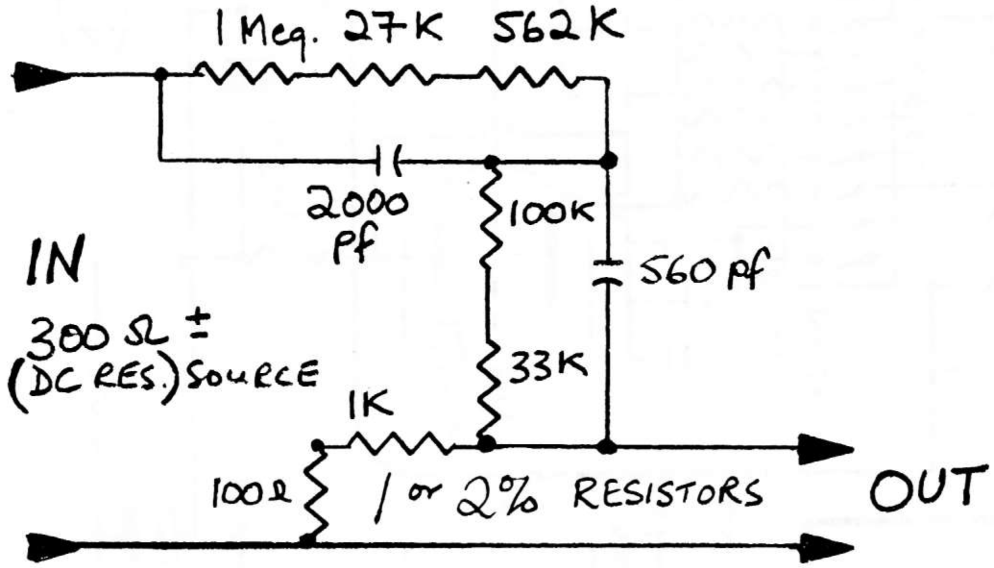
PHONO-STAGE AS IN "DE LUXE"



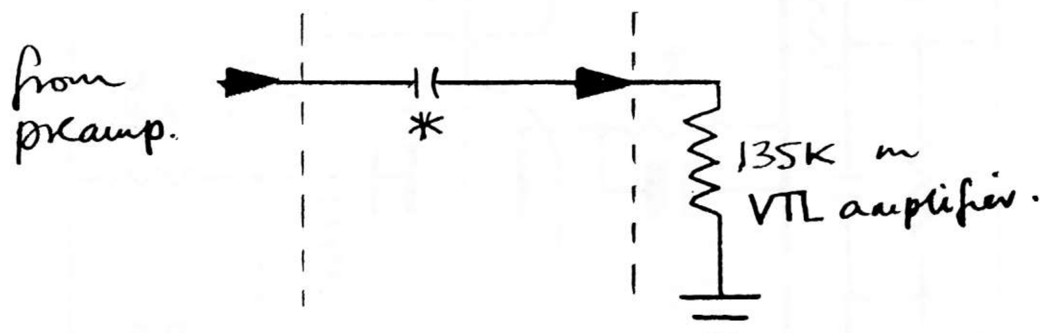
VTL

A USEFUL RIAA - INVERSE TEST NETWORK

NOTES 1 ACCURATE TO WITHIN ·3 dB ONLY
2 INSERTION-LOSS 44 dB @ 1 kHz

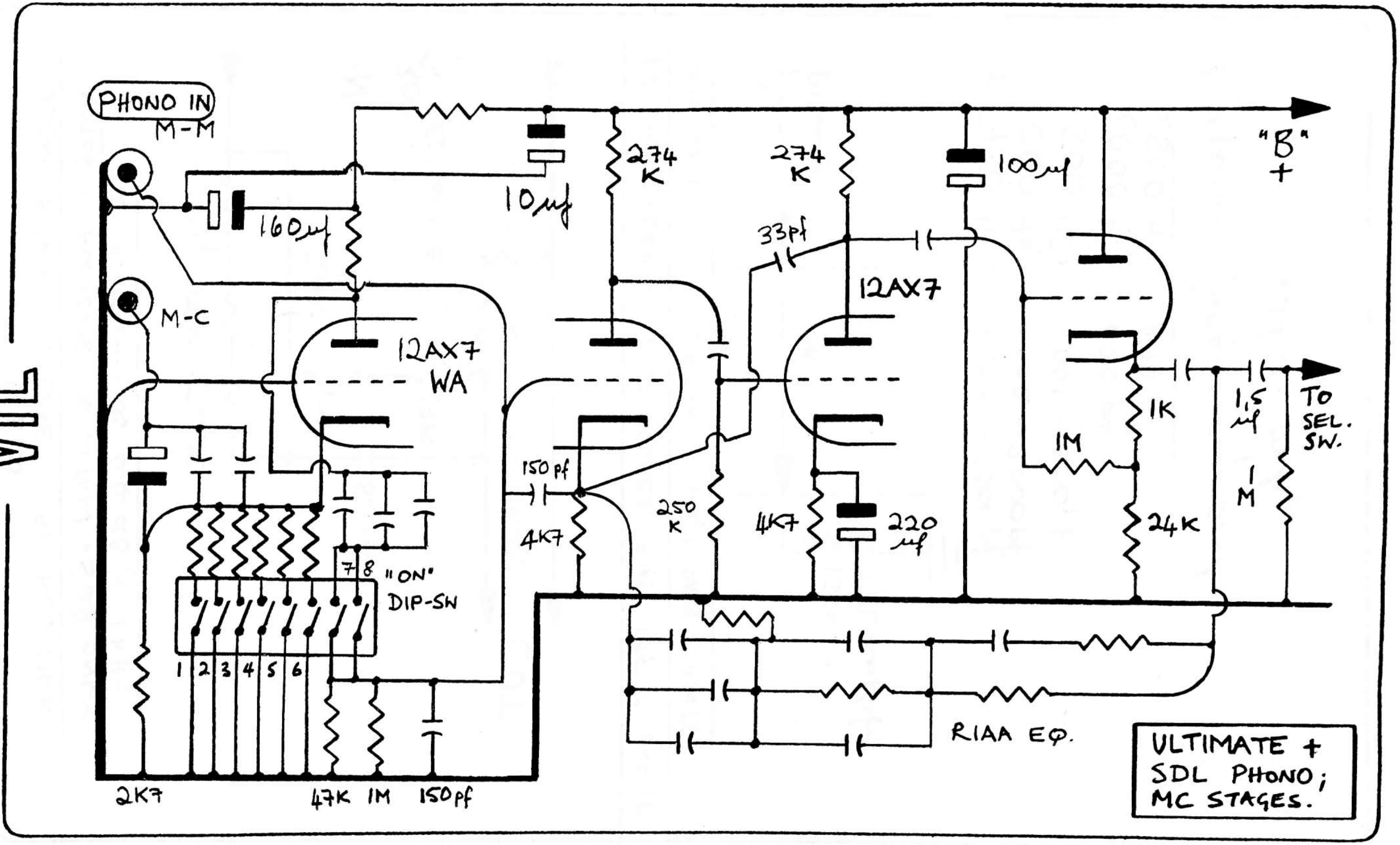


IN-LINE (SERIES) CAP. VALUES FOR 135 K INPUT IMPEDANCE at VARIOUS HIGH-PASS POINTS

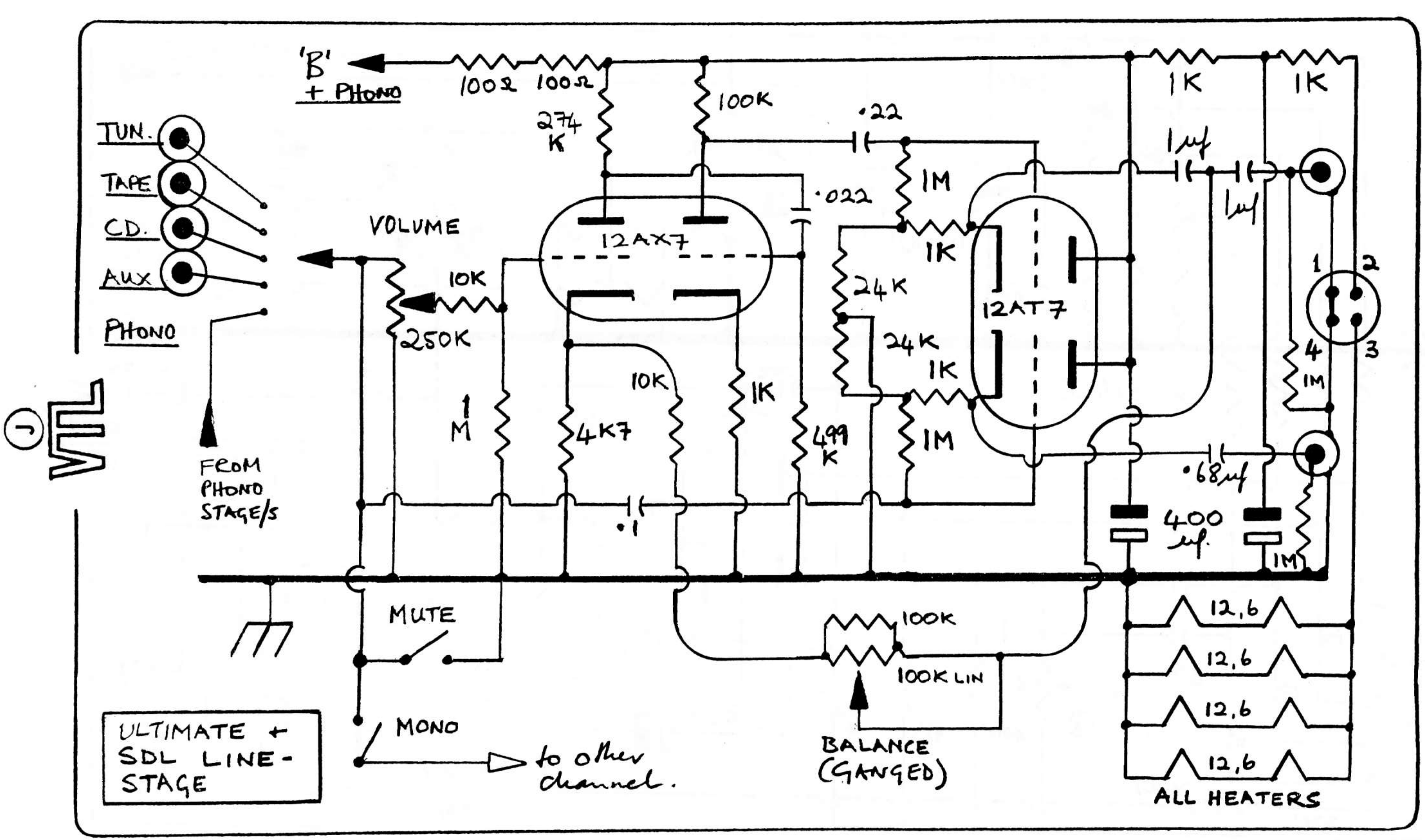


* 750 Hz:	·003 – 3000 pf
1000 Hz:	·002 – 2000 pf
1500 Hz:	·001 – 1000 pf
2000 Hz:	680 pf.
2500 Hz:	470 pf.

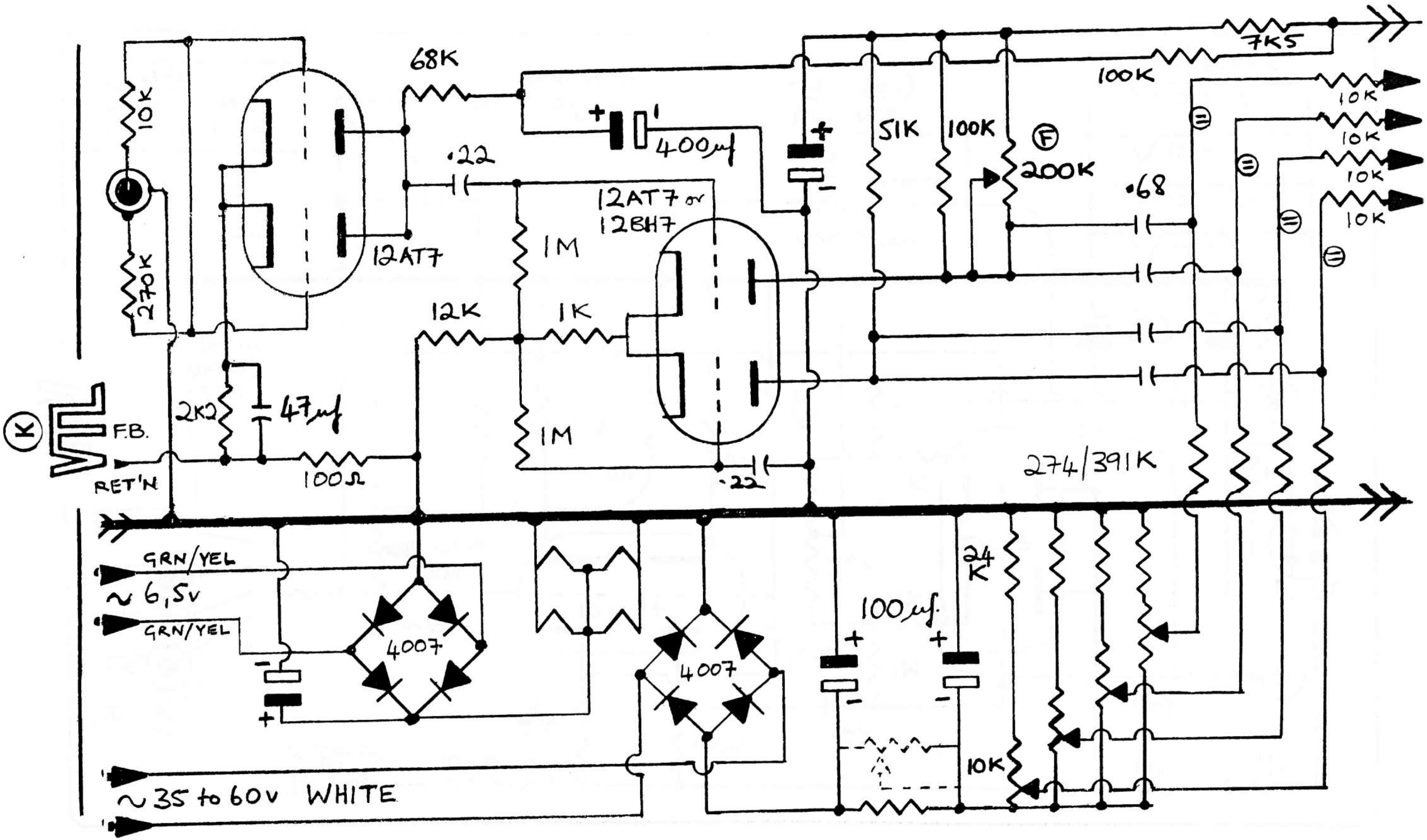
* approx. frequency and values only.



ULTIMATE + SDL PHONO; MC STAGES.



J
VTL
'B'
+ PHONO
100Ω
100Ω
274 K
100K
·22
1K
1K
TUN.
TAPE
C.D.
AUX
PHONO
VOLUME
10K
250K
12AX7
·022
1M
1K
24K
24K
1K
12AT7
1μf
1μf
1
2
3
4
1M
1 M
4K7
10K
1K
499 K
1M
·68μf
400 μf.
1M
FROM PHONO STAGE/S
·1
MUTE
100K
100K LIN
12,6
12,6
12,6
12,6
ALL HEATERS
MONO
to other channel.
BALANCE (GANGED)
ULTIMATE + SDL LINE-STAGE



K
VTL
F.B.
RET'N
10K
270K
2KΩ
47µf
100Ω
68K
12AT7
.22
1M
12K
1K
1M
12AT7 or 12BH7
.22
400µf
51K
100K
F
200K
.68
100K
7K5
10K
10K
10K
10K
274/391K
GRN/YEL
~6,5v
GRN/YEL
4007
4007
100µf
24K
10K
~35 to 60v WHITE

(L)

VTL

TYPICAL INPUT and DRIVER STAGES

AS USED IN ALL AMPLIFIERS (INCLUDES BIAS MIXER and DC HEATER-SUPPLY)

WITH FOLLOWING SPECIFIC NOTATIONS

(A) Triode amplifiers use 12BH7 driver;

(B) ICHIBAN has 2 × 12BH7 PARALLELED

(C) 500 watt MONOBLOCK has a SEPARATE PARALLEL DRIVER FOR EACH HEXAGON OUTPUT BANK (IE ONE PER PHASE)

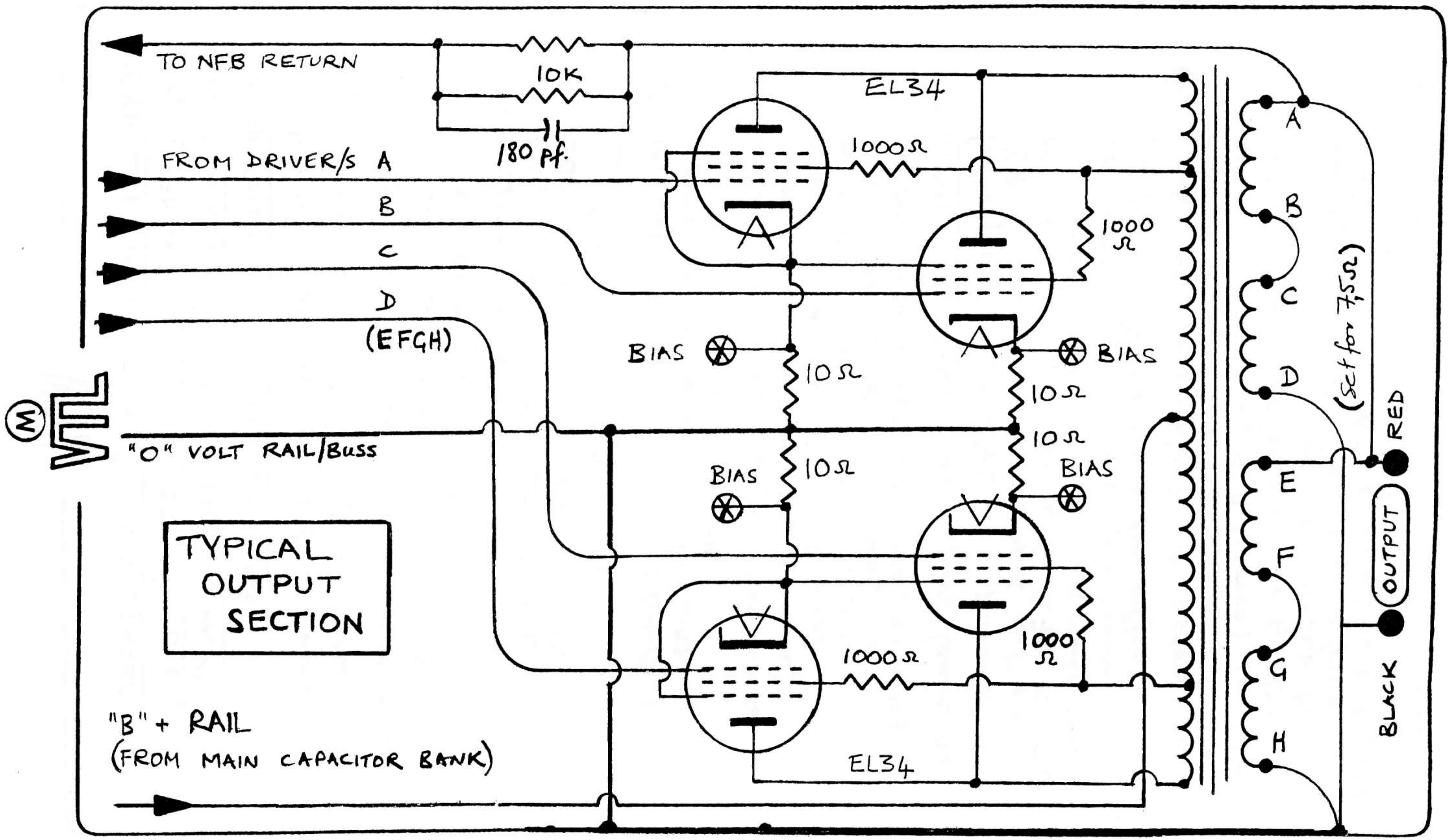
(D) 100/120 MONOBLOCKS USE 274K:
160/300 MONOBLOCKS USE 392K:
500 Watt MONOBLOCKS USE 475K:
AS BIAS-MIXER SPLITTERS

(E) 100 watt, 50 and 60 watt COMPACT MONOBLOCKS have a 'MASTER-BIAS' CONTROL SHOWN DOTTED LINES

(F) 200K CERMET POT ON ALL MONOBLOCKS IS FOR ADJUSTING EQUAL AC BALANCE (PROGRAM/SIGNAL VOLTS RMS) TO GRIDS OF OUTPUT TUBES : SET AT ARBITRARY LEVEL (SAY 20V RMS) @ 1KHz ON VTVM - VACUUM TUBE VOLT-METER, POINTS ⊜

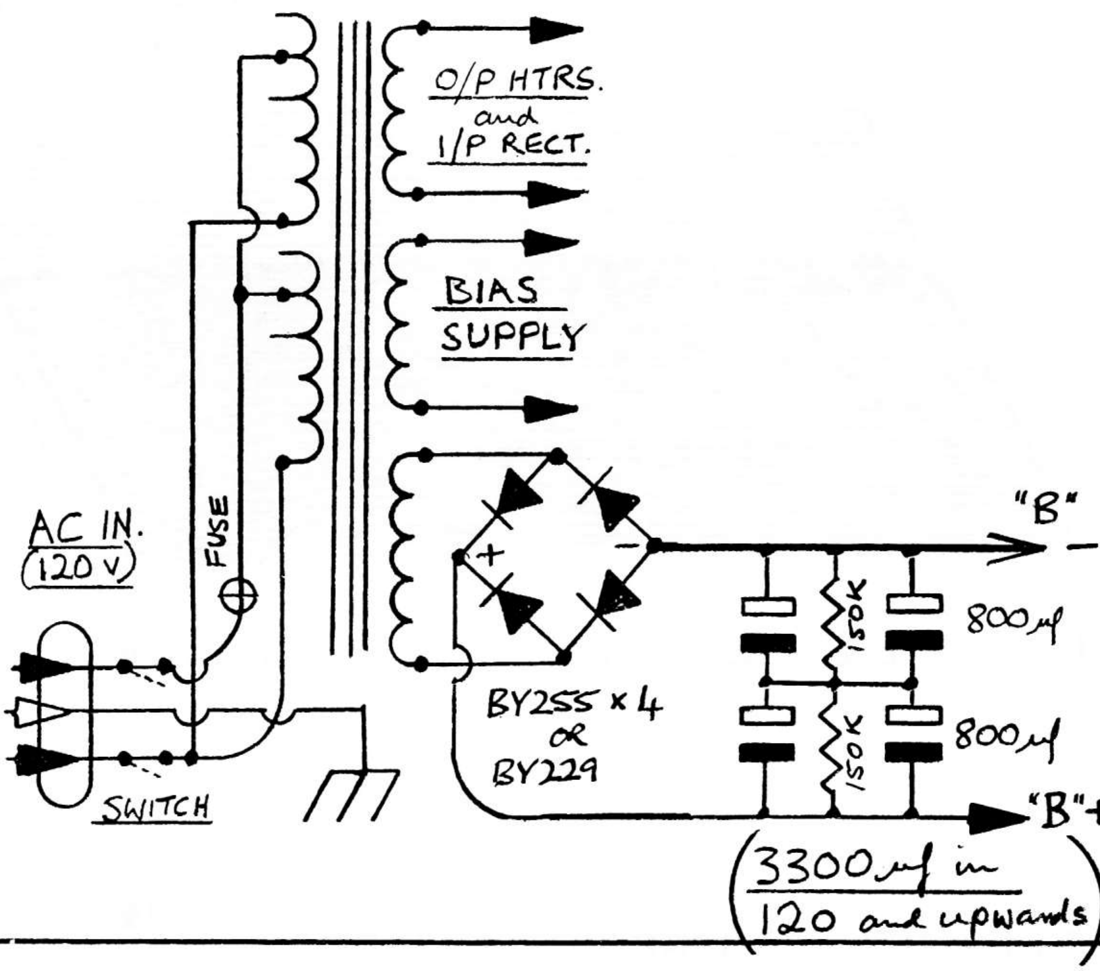
(G) INPUT IMPEDANCE: Amplifiers leave the factory with 2 × 274K in parallel i.e. 137K. One can be clipped out to re-set input impedance to 274K; OR any OTHER resistor of 47K upwards can be fitted if required for crossover purposes with no harmful effect.

(H) BIAS: Set conservatively at factory to approx. 25/27 mA (·25VDC across 10Ω RESISTOR, ·125 across 5Ω RESISTOR) for EL34-6CA7's and 30/35 mA for 6550's. Bias current can be INCREASED to double and triple those figures (moving nearer to CLASS "A" operation) but to NO SONIC BENEFIT; and shortening tube-life thereby.

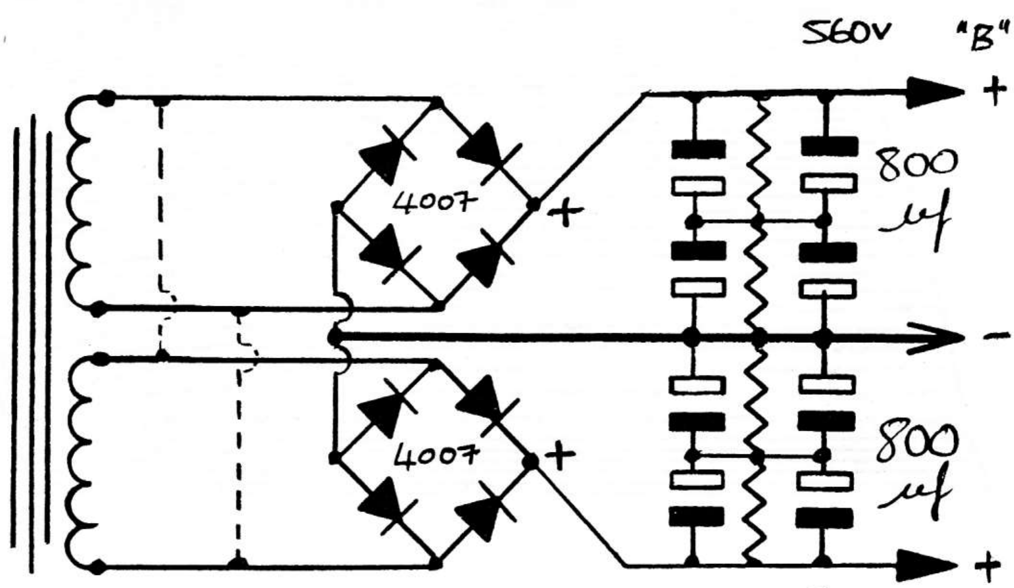


TO NFB RETURN
10K
180 pf.
FROM DRIVER/S A
B
C
D
(EFGH)
EL34
1000Ω
1000 Ω
BIAS
10Ω
10Ω
BIAS
10Ω
BIAS
10Ω
BIAS
"O" VOLT RAIL/BUSS
TYPICAL OUTPUT SECTION
1000Ω
1000 Ω
EL34
"B" + RAIL
(FROM MAIN CAPACITOR BANK)
A
B
C
D
E
F
G
H
(Set for 7,5Ω)
RED
OUTPUT
BLACK

TYPICAL MONOBLOCK SUPPLY (100W)



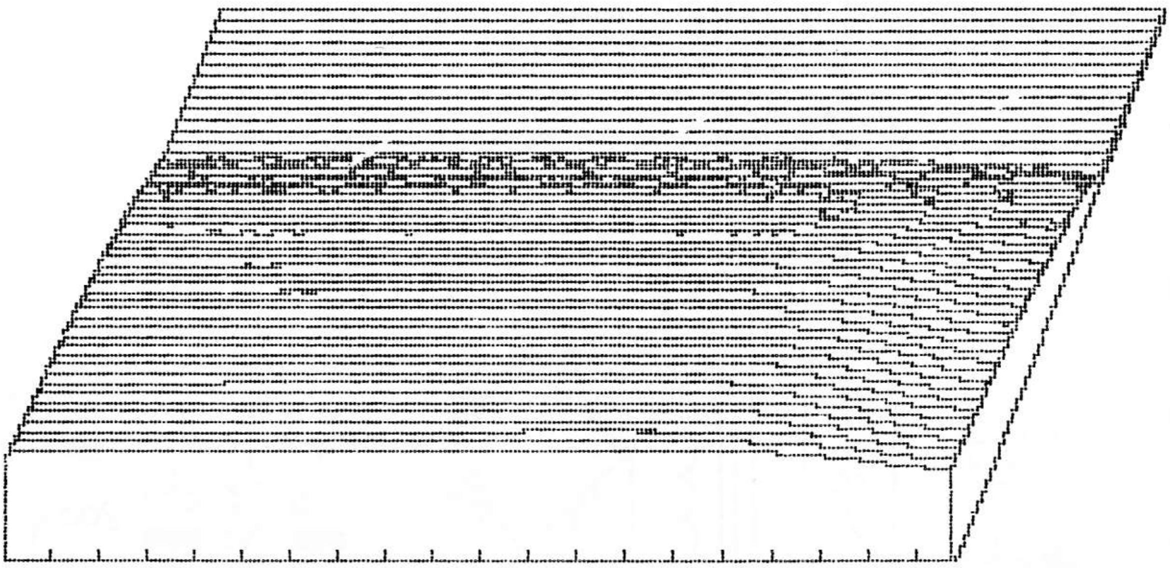
TYPICAL STEREO AMP SUPPLY (75/75)



1 Plot = 4 µsec

File:VTL COMPACT 100.1(P/

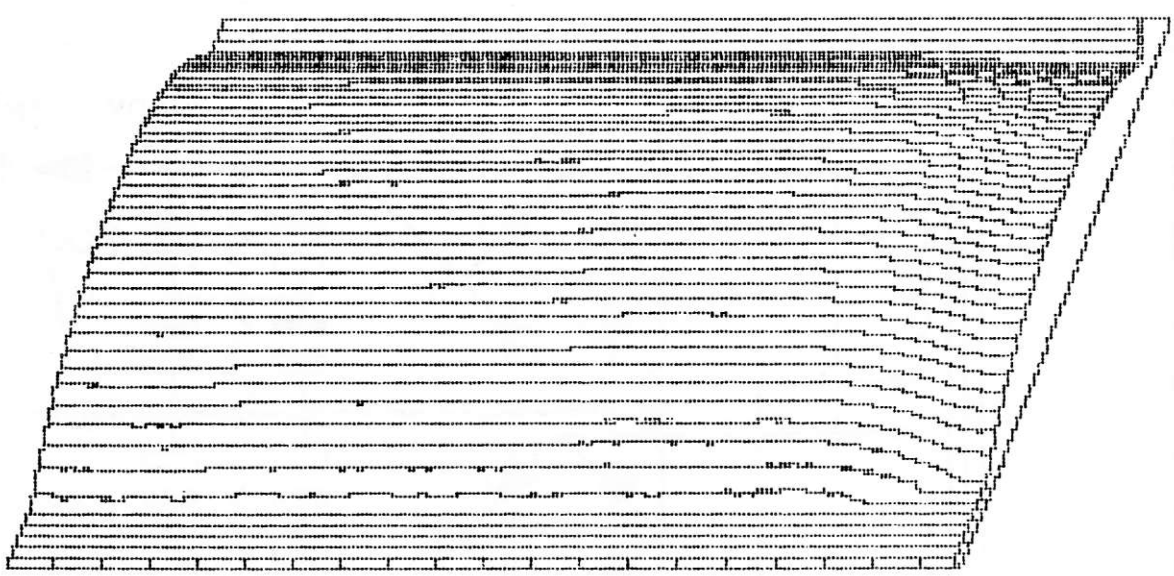
DS=1 S=128

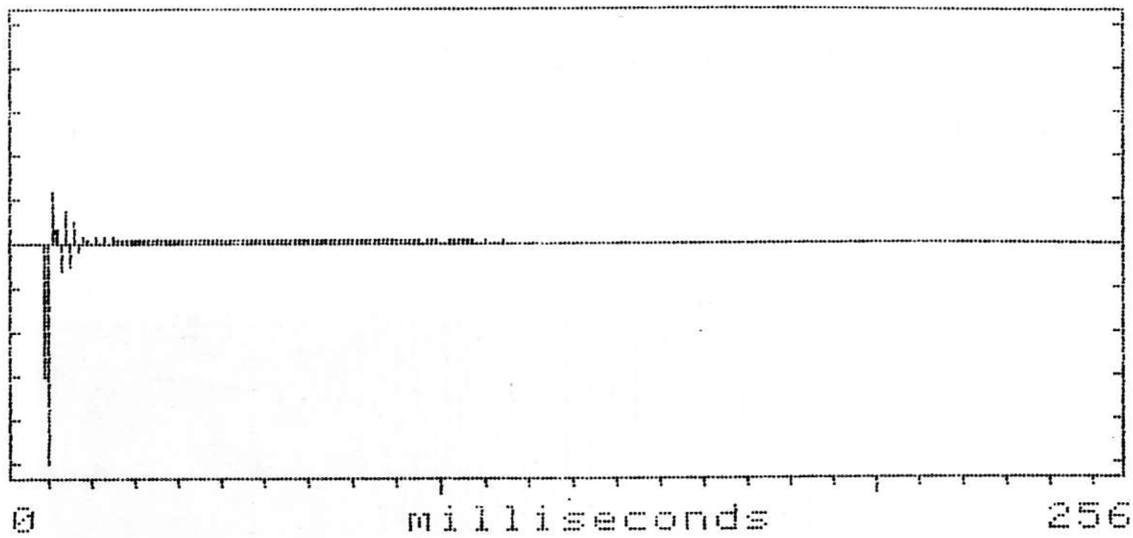


12 µsec

File:VTL COMPACT 100.3(P/

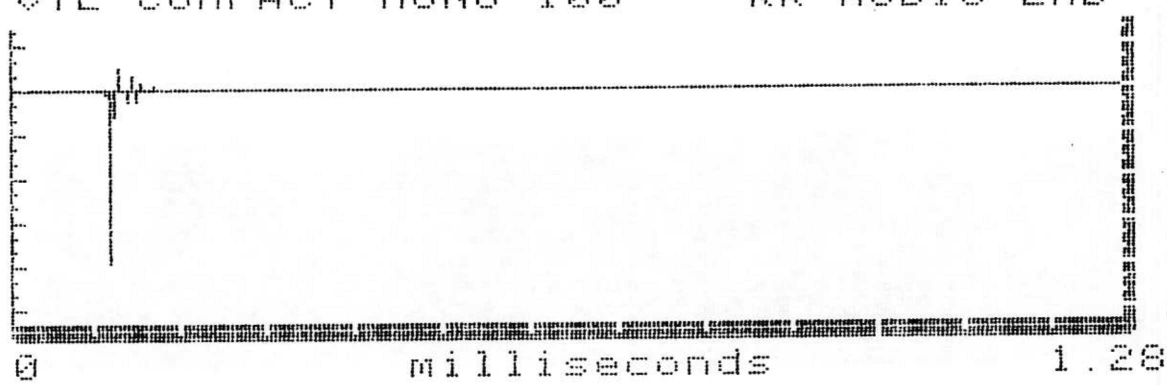
DS=3 S=128

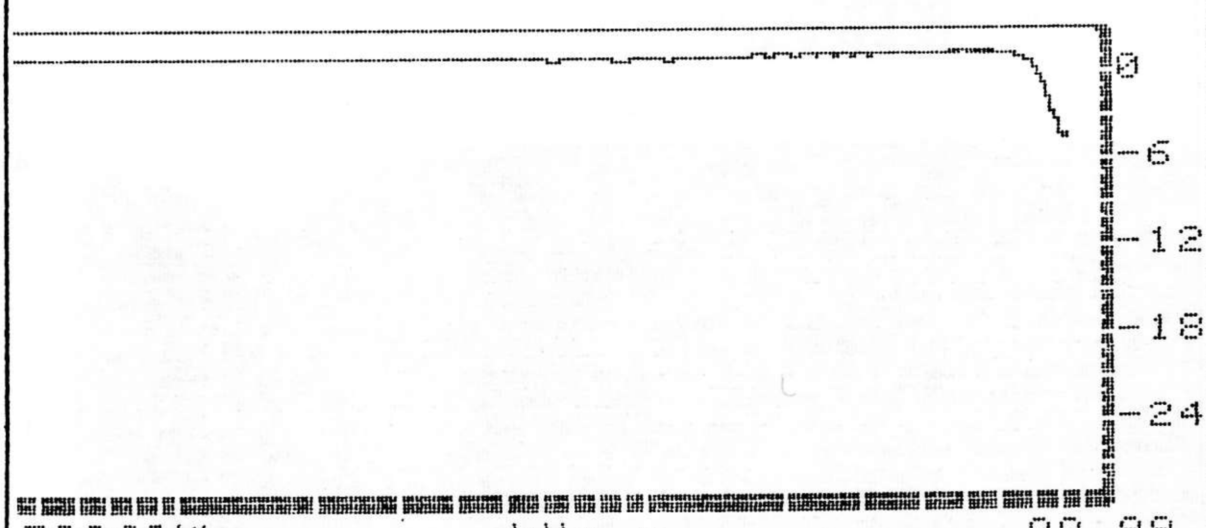




TRANSIENT RESPONSE

VTL COMPACT MONO 100 RR AUDIO LAB



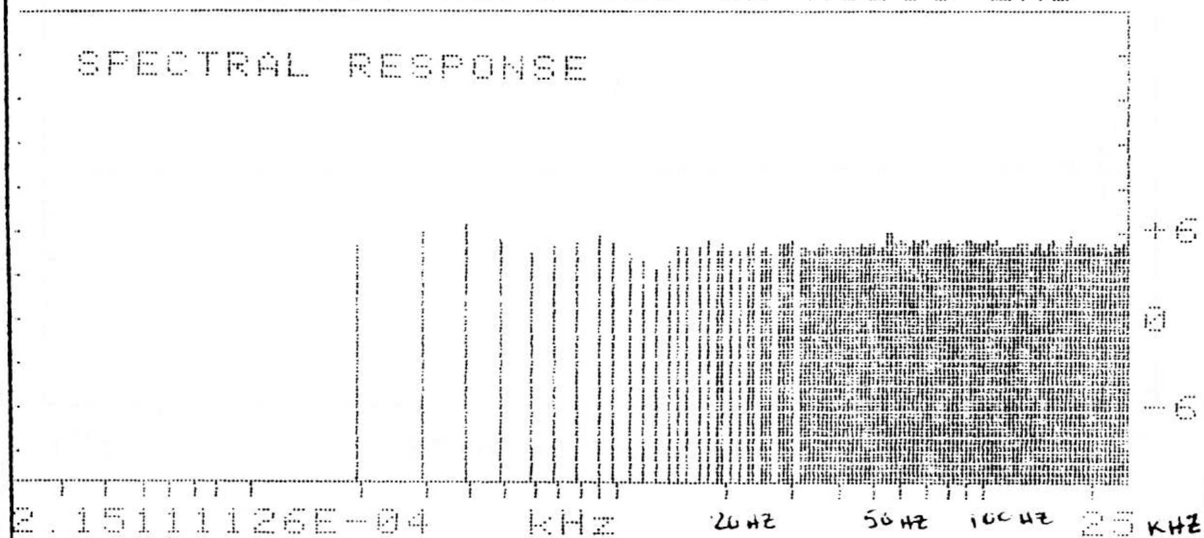


TP= [illegible] msec
N= [illegible] points
T= [illegible] msec
Start= [illegible] msec

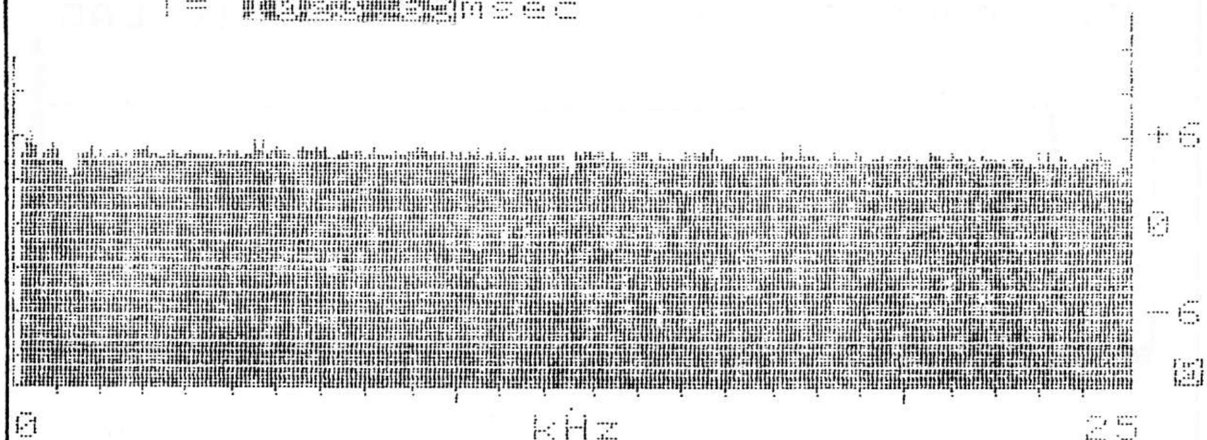
LOG SPECTRUM RR AUDIO LAB

VTL COMPACT MONO 100 RR AUDIO LAB

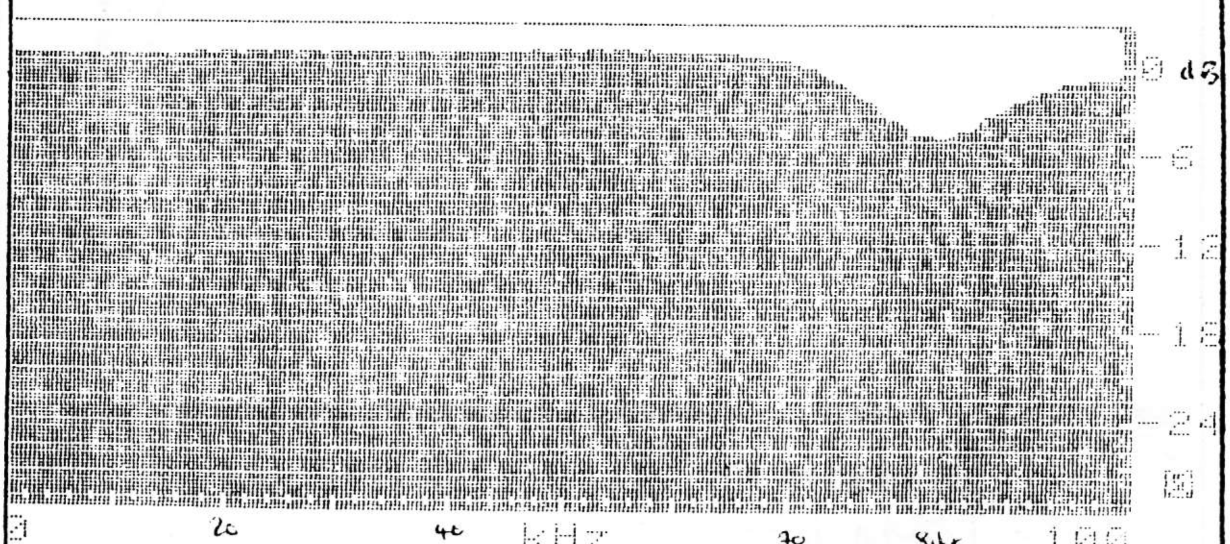
SPECTRAL RESPONSE



TP= [illegible] msec
N= 1024 points
T= [illegible] msec



TP= [illegible] msec
N= 1024 points
T= [illegible] msec

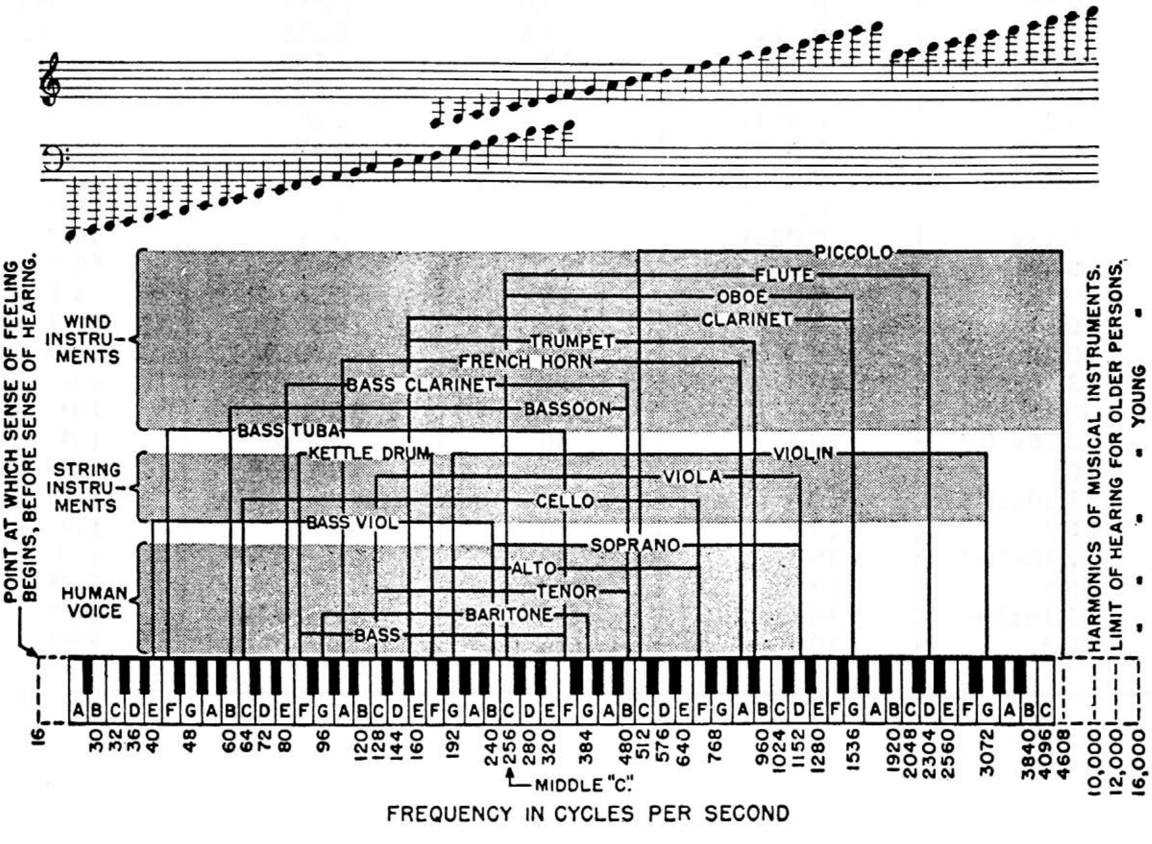


TP= [illegible] msec
N= 512 points
T= [illegible] msec
Start= 0 msec

VTL®

THE SOUND LEVEL METER

Source or Description of Noise		Noise Level in Decibels
Threshold of Pain		130
Hammer Blows on Steel Plate	2 ft.	114
Riveter	35 ft.	97
7-passenger sedan car†		87
Factory		78
Busy street traffic		68
Large office		65
Ordinary conversation	3 ft.	65
Large store		63
Factory office		63
Medium store		62
Restaurant		60
Residential street		58
Medium office		58
Garage		55
Small store		52
Theatre (with audience)		42
Hotel		42
Apartment		42
House, large city		40
House, country		30
Average whisper	4 ft.	20
Quiet whisper	5 ft.	10
Rustle of leaves in gentle breeze		10
Threshold of hearing		0

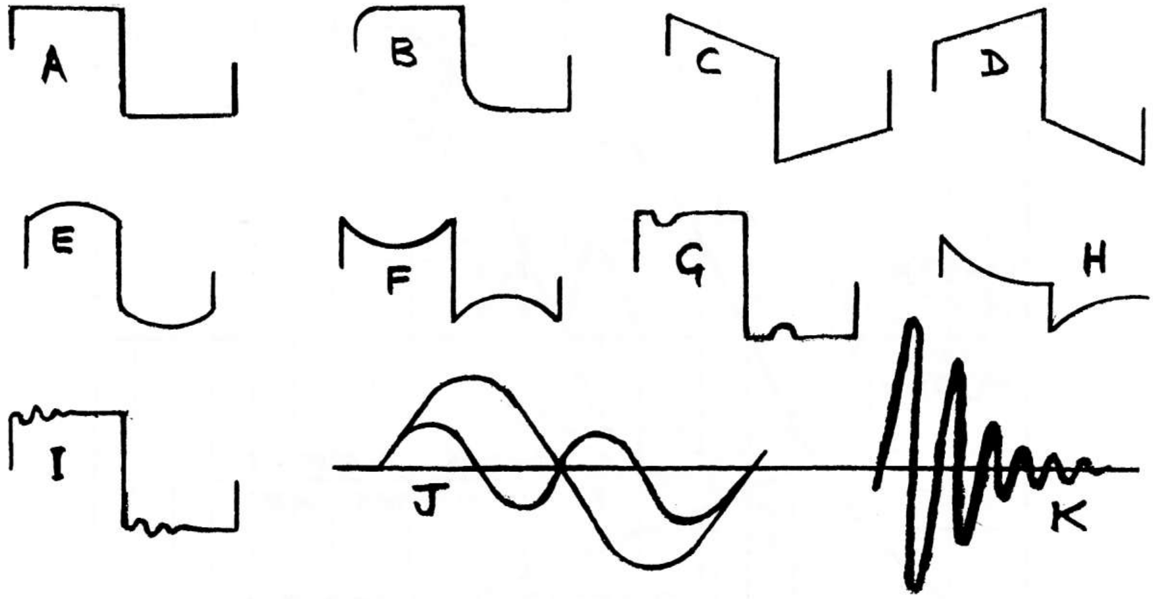


DECIBEL TABLE

Voltage Ratio (Equal Impedance)	Power Ratio	← − db + →	Voltage Ratio (Equal Impedance)	Power Ratio
1.000	1.000	0	1.000	1.000
0.989	0.977	0.1	1.012	1.023
0.977	0.955	0.2	1.023	1.047
0.966	0.933	0.3	1.035	1.072
0.955	0.912	0.4	1.047	1.096
0.944	0.891	0.5	1.059	1.122
0.933	0.871	0.6	1.072	1.148
0.923	0.851	0.7	1.084	1.175
0.912	0.832	0.8	1.096	1.202
0.902	0.813	0.9	1.109	1.230
0.891	0.794	1.0	1.122	1.259
0.841	0.708	1.5	1.189	1.413
0.794	0.631	2.0	1.259	1.585
0.750	0.562	2.5	1.334	1.778
0.708	0.501	3.0	1.413	1.995
0.668	0.447	3.5	1.496	2.239
0.631	0.398	4.0	1.585	2.512
0.596	0.355	4.5	1.679	2.818
0.562	0.316	5.0	1.778	3.162
0.531	0.282	5.5	1.884	3.548
0.501	0.251	6.0	1.995	3.981
0.473	0.224	6.5	2.113	4.467
0.447	0.200	7.0	2.239	5.012
0.422	0.178	7.5	2.371	5.623
0.398	0.159	8.0	2.512	6.310
0.376	0.141	8.5	2.661	7.079
0.355	0.126	9.0	2.818	7.943
0.335	0.112	9.5	2.985	8.913
0.316	0.100	10	3.162	10.00
0.282	0.0794	11	3.55	12.6
0.251	0.0631	12	3.98	15.9
0.224	0.0501	13	4.47	20.0
0.200	0.0398	14	5.01	25.1
0.178	0.0316	15	5.62	31.6
0.159	0.0251	16	6.31	39.8
0.141	0.0200	17	7.08	50.1
0.126	0.0159	18	7.94	63.1
0.112	0.0126	19	8.91	79.4
0.100	0.0100	20	10.00	100.0
3.16×10^{-2}	10^{-3}	30	3.16×10	10^{3}
10^{-2}	10^{-4}	40	10^{2}	10^{4}
3.16×10^{-3}	10^{-5}	50	3.16×10^{2}	10^{5}
10^{-3}	10^{-6}	60	10^{3}	10^{6}
3.16×10^{-4}	10^{-7}	70	3.16×10^{3}	10^{7}
10^{-4}	10^{-8}	80	10^{4}	10^{8}
3.16×10^{-5}	10^{-9}	90	3.16×10^{4}	10^{9}
10^{-5}	10^{-10}	100	10^{5}	10^{10}
3.16×10^{-6}	10^{-11}	110	3.16×10^{5}	10^{11}
10^{-6}	10^{-12}	120	10^{6}	10^{12}

VTL

OSCILLOGRAMS



EXAGGERATED DRAWINGS!

LEGEND: (A) The perfect square-wave, as it goes in and should come OUT.

(B) "Rounding" indicates H.F. drop-off

(C) Phase-shift; phase "leads"

(D) Phase-shift; phase "Lags"

(E) Accentuated gain at Low Frequencies

(F) Loss of gain at Low Frequencies

(G) "Dip" Loss of gain in a narrow frequency range.

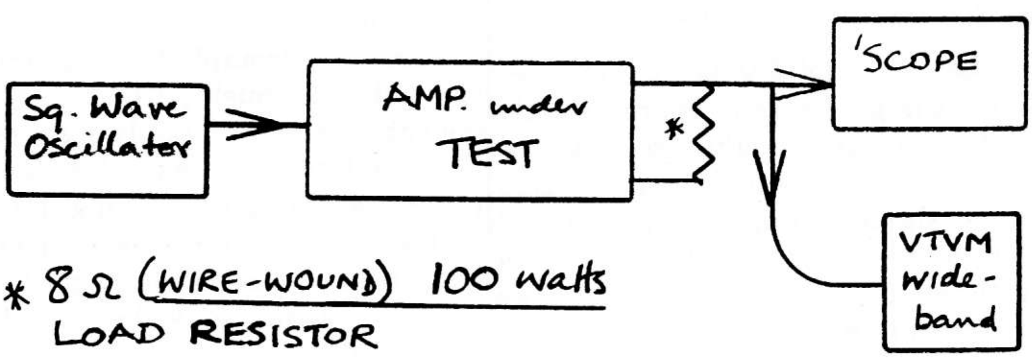
(H) "Differentiation" — poor coupling caps.

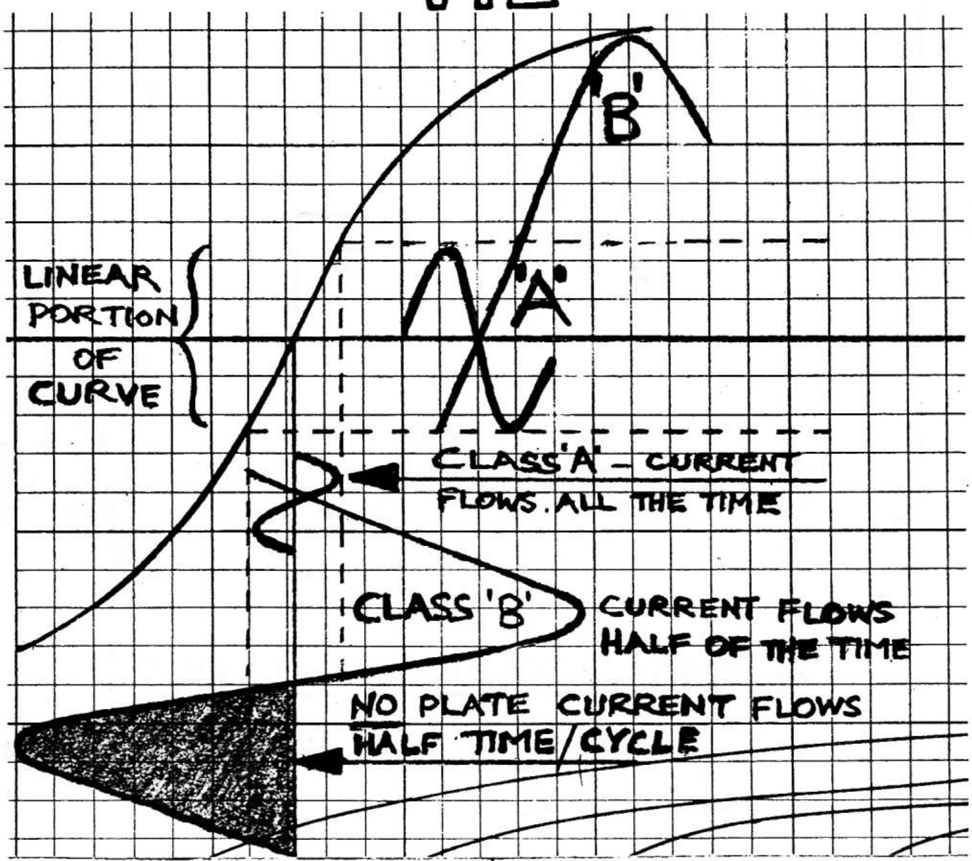
(I) "Overshoot" or "Ringing" — poor transients.

(J) Sine-wave, with second harmonic.

(K) Slow transient ringing and slow decay.

SET-UP





Class A Amplifier is one in which the grid bias and signal voltages are such that the plate current in the tube, or in each tube of a push-pull stage flows at all times.

This is accomplished by operating at the center point of the plate current vs. grid voltage curve and using signal voltages which do not drive the grid into either the positive-region or into the sharp bend near cut-off voltage.

Class A2 Amplifier is the same as a Class A1 amplifier except that the signal may drive the grid into the positive region. This is accomplished by operating at a lower bias than the center point which would have been selected for class A operation.

Class B Amplifier is an amplifier in which the grid bias is approximately equal to the cut-off value, so that the plate current is approximately zero when no signal voltage is applied and so that plate current in the tube or in each tube of a push-pull stage, flows for approximately one-half of each cycle when an alternating grid voltage is applied.

An important characteristic is that the grid circuit draws appreciable power which prevents it from being used with ordinary resistance coupled driver tubes.

Class AB1 Amplifier is one in which the grid bias and peak signal voltage are in such proportion that it operates as a Class A amplifier for small signals and as a Class B Amplifier for large signals.

Class AB2 Amplifier is one in which the signal is allowed to drive the grid slightly into the positive region but not enough to require appreciable power from the driver.

This is accomplished by operating two tubes in push-pull at very nearly the cut-off bias and applying a peak signal equal to the bias. Resistance coupling may be used making this is the best way of obtaining large power output with low distortion. A good example of this rating may be found under Type 6L6G.

COLOR CODE

Color	First Digit	Second Digit	Multiplier	Tolerance (±)
Black	—	0	1	—
Brown	1	1	10	1%
Red	2	2	100	2%
Orange	3	3	1,000	3%
Yellow	4	4	10,000	4%
Green	5	5	100,000	
Blue	6	6	1,000,000	
Violet	7	7	10,000,000	
Gray	8	8	100,000,000	
White	9	9	1,000,000,000	
Silver				10%
Gold				5%
No color				20%

RESISTANCE OF WIRE

AWG	Ohms per 1000 ft. at 20°C., or 68°F.
8	0.6282
9	0.7921
10	0.9989
11	1.260
12	1.588
13	2.003
14	2.525
15	3.184
16	4.016
17	5.064
18	6.385
19	8.051
20	10.15
21	12.80
22	16.14
23	20.36
24	25.67
25	32.37
26	40.81
27	51.47
28	64.90
29	81.83
30	103.2
31	130.1
32	164.1

RIAA EQUALIZATION

HZ	DB
20	+19,27
30	18,59
40	17,79
50	16,95
60	16,10
70	15,28
80	14,51
100	13,09
125	11,56
150	10,27
200	8,22
250	6,68
300	5,48
400	3,78
500	2,65
600	1,84
700	1,23
800	0,75
900	0,35
1000	ZERO 0,00
1500	— 1,40
2000	- 2,59
3000	- 4,74
4000	- 6,61
5000	- 8,21
6000	- 9,60
7000	- 10,82
8000	- 11,89
9000	- 12,86
10000	- 13,73
11000	- 14,53
12000	- 15,26
13000	- 15,94
14000	- 16,57
15000	- 17,16
16000	- 17,71
17000	- 18,23
18000	- 18,72
19000	- 19,18
20000	- 19,62

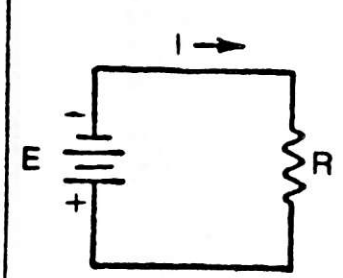
HANDY TABLE FOR DETERMINING
POWER — VOLTAGE — CURRENT — RESISTANCE
TO DETERMINE

	VOLTAGE IN VOLTS	CURRENT IN AMPERES	RESISTANCE IN OHMS	POWER IN WATTS
1	KNOWN	KNOWN	$\frac{E}{I}$	$E \times I$
2	KNOWN	$\frac{E}{R}$	KNOWN	$\frac{E^2}{R}$
3	KNOWN	$\frac{W}{E}$	$\frac{E^2}{W}$	KNOWN
4	$I \times R$	KNOWN	KNOWN	$I^2 R$
5	$\frac{W}{I}$	KNOWN	$\frac{W}{I^2}$	KNOWN
6	$\sqrt{R \times W}$	$\sqrt{\frac{W}{R}}$	KNOWN	KNOWN

DC CIRCUITS

Ohms's law
R is in ohms; I in amperes; E in volts
P in watts

$I = E/R = P/E = \sqrt{P/R}$
$R = E/I = P/I^2 = E^2/P$
$E = IR = P/I = \sqrt{PR}$
$P = EI = E^2/R = I^2R$



$E_C = I \times X_c$
$E_L = I \times X_L$
$E_R = I \times R$
$E_{source} = I \times Z$

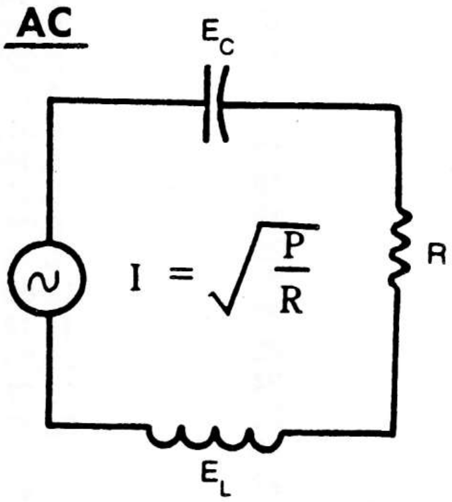
Impedance

$Z = E/I$

Current

$I = E/Z$

AC



True Power

$$P = \frac{E^2 \times \cos \phi}{Z}$$

$$P = I^2 \times Z \times \cos \phi$$

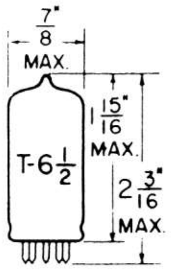
$$I = \sqrt{\frac{P}{E \times \cos \phi}}$$

$$I = \sqrt{\frac{P}{Z \times \cos \phi}}$$

TUNG-SOL

DOUBLE TRIODE

MINIATURE TYPE



GLASS BULB

COATED UNIPOTENTIAL CATHODES

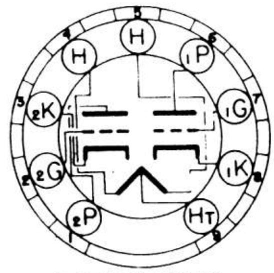
HEATER

SERIES	PARALLEL
12.6 VOLTS	6.3 VOLTS
150 MA.	300 MA.

AC OR DC

FOR 12.6 VOLT OPERATION APPLY HEATER VOLTAGE BETWEEN PINS #4 AND #5. FOR 6.3 VOLT OPERATION APPLY HEATER VOLTAGE BETWEEN PIN #9 AND PINS #4 AND #5 CONNECTED TOGETHER.

ANY MOUNTING POSITION



BOTTOM VIEW

SMALL BUTTON
9 PIN BASE
9A

THE 12AT7 COMBINES TWO HIGH TRANSCONDUCTANCE TRIODES IN A 9 PIN MINIATURE CONSTRUCTION. ITS LOW CAPACITANCE AND HIGH RATIO OF PLATE CURRENT TO TRANSCONDUCTANCE ADAPT IT TO USE AS A HIGH FREQUENCY COMBINED OSCILLATOR AND MIXER OR AS A GROUNDED GRID RADIO FREQUENCY AMPLIFIER.

DIRECT INTERELECTRODE CAPACITANCES

	WITHOUT SHIELD	WITH SHIELD #316[A]	
INPUT: G TO (H+K) (EACH SECTION)	2.2	2.2	μμf
OUTPUT: P TO (H+K) (SECTION #1)	0.5	1.2	μμf
(SECTION #2)	0.4	1.5	μμf
GRID TO PLATE: (G TO P) (EACH SECTION)	1.5	1.5	μμf
HEATER TO CATHODE: (H TO K) (EACH SECTION)	2.4	2.4	μμf

GROUNDED GRID	WITHOUT SHIELD	WITH SHIELD #316[B]	
INPUT: K TO (H+G) (EACH SECTION)	4.6	4.6	μμf
OUTPUT: P TO (H+G) (EACH SECTION)	1.8	2.6	μμf
PLATE TO CATHODE (P TO K) (EACH SECTION)	0.2	0.2	μμf

[A] CONNECTED TO CATHODE OF SECTION UNDER TEST.

[B] CONNECTED TO GRID OF SECTION UNDER TEST.

RATINGS

INTERPRETED ACCORDING TO RMA STANDARD M8-210

EACH TRIODE UNIT

HEATER VOLTAGE	12.6	6.3	VOLTS
MAXIMUM HEATER—CATHODE VOLTAGE	90		VOLTS
MAXIMUM PLATE VOLTAGE	300		VOLTS
MAXIMUM NEGATIVE DC GRID VOLTAGE	-50		VOLTS
MAXIMUM PLATE DISSIPATION	2.5		WATTS

CONTINUED ON FOLLOWING PAGE

→ INDICATES A CHANGE OR ADDITION.

TUNG-SOL

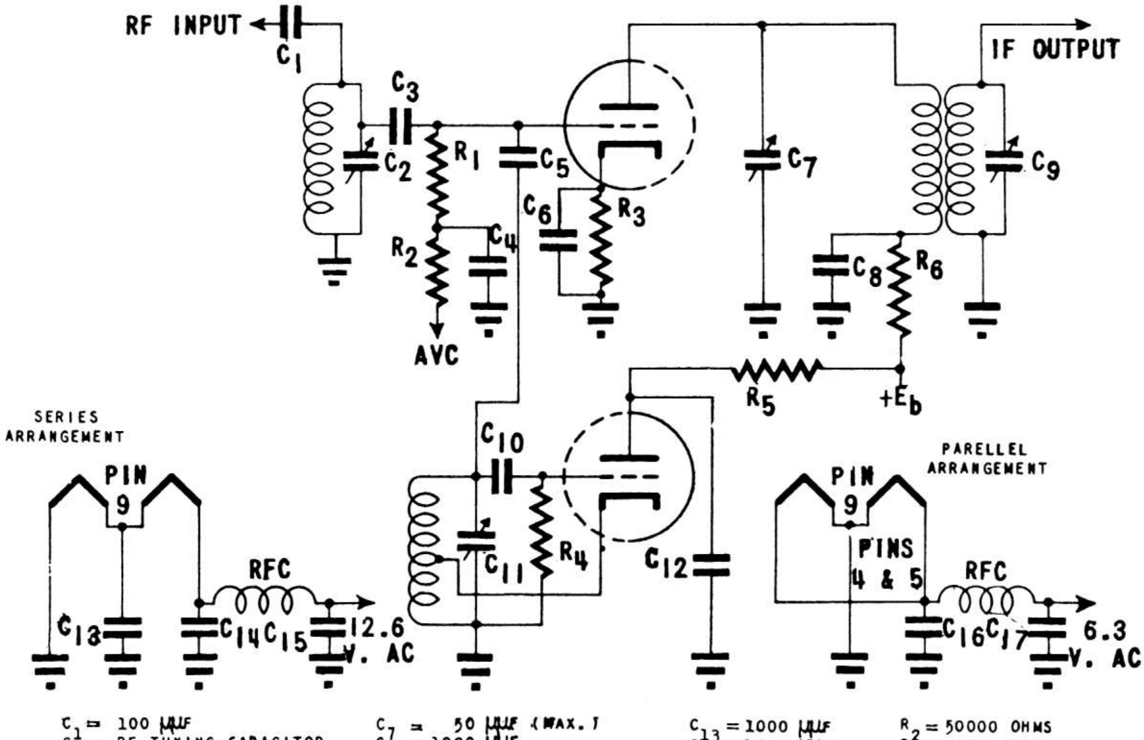
CONTINUED FROM PRECEDING PAGE

TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS

CLASS A_1 AMPLIFIER – EACH TRIODE UNIT

HEATER VOLTAGE	12.6	6.3	12.6	6.3	VOLTS
HEATER CURRENT	150	300	150	300	MA.
PLATE VOLTAGE	100		250		VOLTS
CATHODE BIAS RESISTOR	270		200		OHMS
PLATE CURRENT	3.7		10		MA.
PLATE RESISTANCE	15 000		10 900		OHMS
TRANSCONDUCTANCE	4 000		5 500		µMHOS
AMPLIFICATION FACTOR	60		60		
GRID VOLTAGE (APPROX.) FOR I_b = 10 µA.	−5		−12		VOLTS

TYPICAL CIRCUIT FOR CONVERTER OPERATION AT 100 MEGACYCLES



C_1 = 100 µµF
C_2 = RF TUNING CAPACITOR
C_3 = 25 µµF
C_4 = 1000 µµF
C_5 = 1 µµF
C_6 = 1000 µµF

C_7 = 50 µµF (MAX.)
C_8 = 1000 µµF
C_9 = 50 µµF (MAX.)
C_{10} = 50 µµF
C_{11} = OSCILLATOR TUNING CAPACITOR
C_{12} = 1000 µµF

C_{13} = 1000 µµF
C_{14} = 1000 µµF
C_{15} = 1000 µµF
C_{16} = 1000 µµF
C_{17} = 1000 µµF
R_1 = 50000 OHMS

R_2 = 50000 OHMS
R_3 = 2000 OHMS
R_4 = 10000 OHMS
R_5 = 1000 OHMS
R_6 = 1000 OHMS
E_b = 100 OR 250 VOLTS

OSCILLATOR VOLTAGE APPLIED TO MIXER SHOULD BE JUST SUFFICIENT TO CAUSE GRID CURRENT TO FLOW IN THE MIXER SECTION.

TUNG-SOL

TWIN TRIODE

MINIATURE TYPE

HIGH-MU TRIODES

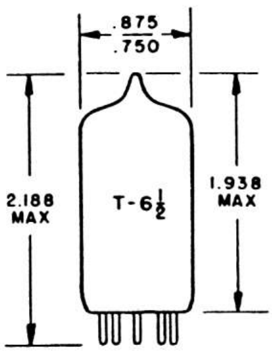
FOR

HIGH GAIN AUDIO AMPLIFIER SERVICE

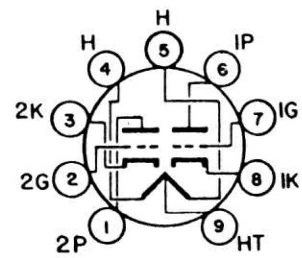
IN MILITARY APPLICATIONS

COATED UNIPOTENTIAL CATHODE

ANY MOUNTING POSITION



GLASS BULB
SMALL BUTTON
9 PIN NOVAL E9-1
OUTLINE DRAWING
JEDEC 6-2



BOTTOM VIEW
BASING DIAGRAM
JEDEC 9A

THE 12AX7WA CONTAINS TWO INDEPENDENT HIGH-MU TRIODES IN THE 9 PIN MINIATURE CONSTRUCTION. IT IS ADAPTABLE TO APPLICATIONS WHERE HIGH VOLTAGE GAIN AND LOW HEATER POWER ARE THE IMPORTANT CONSIDERATION, SUCH AS VOLTAGE AMPLIFIER, PHASE INVERTERS OR MULTIVIBRATORS. THE CENTER TAPPED HEATER CONNECTION PERMITS OPERATION FROM EITHER A 6.3 VOLT OR 12.6 VOLT SUPPLY AND IN 300 MA. OR 150 MA. SERIES HEATER SERVICE.

DIRECT INTERELECTRODE CAPACITANCES

GRID TO PLATE: G TO P	1.7	pf
INPUT	1.8	pf
OUTPUT SECTION 1	0.46	pf
OUTPUT SECTION 2	0.34	pf

HEATER CHARACTERISTICS AND RATINGS

DESIGN MAXIMUM VALUES - SEE EIA STANDARD RS-239

SUPPLY CONNECTED TO PINS	4 AND 5	9 AND 4+5	
AVERAGE VALUES— VOLTAGE	12.6	6.3	VOLTS
— CURRENT	150	300	MA.
LIMITS OF APPLIED VOLTAGE	12.6 ± 1.2	6.3 ± 0.6	VOLTS

MAXIMUM RATINGS

DESIGN MAXIMUM VALUES - SEE EIA STANDARD RS-239

VALUES ARE FOR EACH UNIT

PLATE VOLTAGE	330	VOLTS
PLATE DISSIPATION	1.0	WATT
GRID VOLTAGE		
NEGATIVE BIAS VALUE	-50	VOLTS
POSITIVE BIAS VALUE	0	VOLTS
BULB TEMPERATURE	+165	°C

TUNG-SOL

CONTINUED FROM PRECEDING PAGE

CHARACTERISTICS

CLASS A1 AMPLIFIER

PLATE VOLTAGE	250	VOLTS
GRID VOLTAGE	-2	VOLTS
PLATE CURRENT	1.2	MA.
AMPLIFICATION FACTOR	100	μ
TRANSCONDUCTANCE	1,650	μMHOS
PLATE RESISTANCE	62,500	OHMS

SPECIAL TESTS AND RATINGS

HEATER CYCLING RATING		
ALTITUDE	80,000	FEET
SHOCK		

RESISTANCE COUPLED AMPLIFIER

R_p MEG.	R_s MEG.	R_{g1} MEG.	E_{bb} = 90 VOLTS			E_{bb} = 180 VOLTS			E_{bb} = 300 VOLTS		
			R_k	GAIN	E_o	R_k	GAIN	E_o	R_k	GAIN	E_o
0.10	0.10	0.1	1700	31	5.0	1000	40	15	760	43	30
0.10	0.24	0.1	2000	38	6.9	1100	46	20	900	50	40
0.24	0.24	0.1	3500	43	6.5	2000	54	18	1600	58	37
0.24	0.51	0.1	3900	49	8.6	2300	59	24	1800	64	47
0.51	0.51	0.1	7100	50	7.4	4300	62	19	3100	66	39
0.51	1.0	0.1	7800	53	9.1	4800	64	24	3600	69	46
0.24	0.24	10	0	37	3.9	0	53	15	0	62	32
0.24	0.51	10	0	44	5.4	0	60	19	0	67	41
0.51	0.51	10	0	44	5.0	0	61	17	0	69	35
0.51	1.0	10	0	49	6.4	0	66	21	0	71	41

E_o IS MAXIMUM RMS VOLTAGE OUTPUT FOR FIVE PERCENT TOTAL HARMONIC DISTORTION.

GAIN MEASURED AT 2.0 VOLTS RMS OUTPUT.

FOR ZERO-BIAS DATA, GENERATOR IMPEDANCE IS NEGLIGIBLE.

TUNG-SOL

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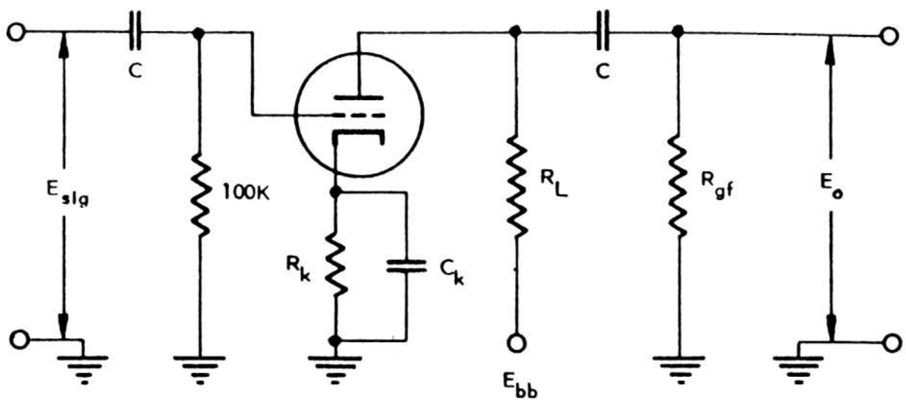
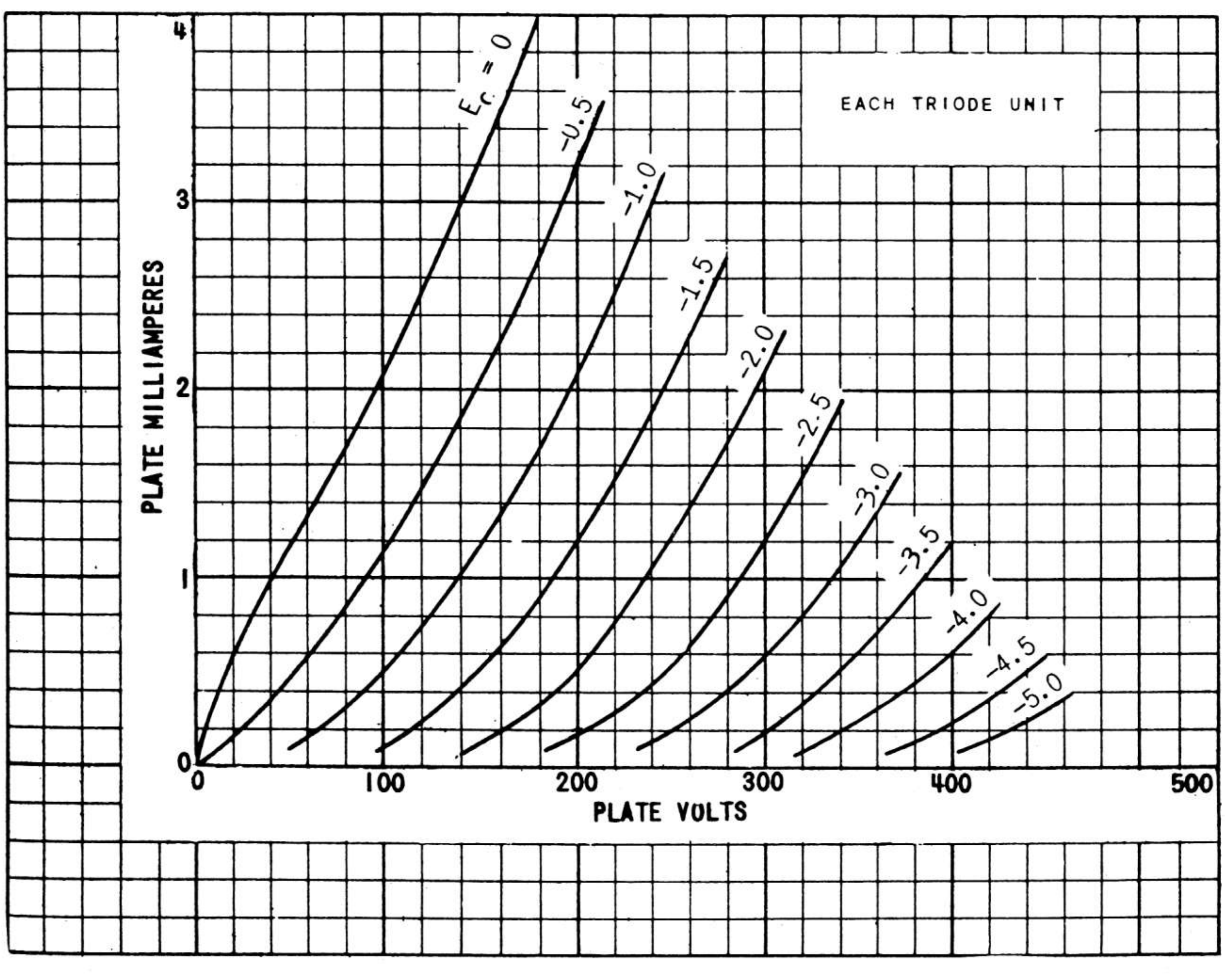
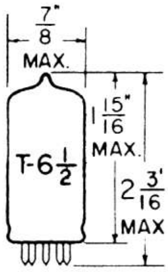


COUPLING CAPACITORS (C) SHOULD BE SELECTED TO GIVE DESIRED FREQUENCY RESPONSE. R_k SHOULD BE ADEQUATELY BY-PASSED.



DOUBLE TRIODE

MINIATURE TYPE



GLASS BULB

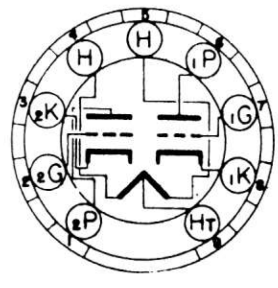
COATED UNIPOTENTIAL CATHODE

HEATER

SERIES	PARALLEL
12.6 VOLTS	6.3 VOLTS
0.175 AMP.	0.35 AMP.

AC OR DC

ANY MOUNTING POSITION



BOTTOM VIEW

MINIATURE BUTTON
9 PIN BASE

9A

THE 5814 IS A 9-PIN MINIATURE, MEDIUM-MU TUBE WITH TWO TRIODE SECTIONS WITH INDIVIDUAL CATHODE CONNECTIONS. IT INCORPORATES DISTINCTIVE MECHANICAL DESIGN FEATURES, AND INCREASED HEATER CURRENT WHICH PROVIDES A SAFETY FACTOR IN CATHODE PERFORMANCE. THESE FEATURES COMBINE TO PRODUCE A STURDY SHOCK-RESISTANT TUBE AND ONE WHICH WILL GIVE LONG LIFE UNDER CONDITIONS OF INTERMITTENT OPERATION.

DIRECT INTERELECTRODE CAPACITANCES

WITH NO EXTERNAL SHIELD

	SECTION #1	SECTION #2	
GRID TO PLATE	1.5	1.5	μμf
INPUT	1.6	1.6	μμf
OUTPUT	0.50	0.35	μμf

RATINGS

INTERPRETED ACCORDING TO RMA STANDARD M8-210

	DESIGN CENTER VALUES		ABSOLUTE MAXIMUM VALUES		
HEATER VOLTAGE	6.3	12.6	6.3	12.6	VOLTS
MAXIMUM PEAK HEATER CATHODE VOLTAGE:					
HEATER NEGATIVE WITH RESPECT TO CATHODE	90		100		VOLTS
HEATER POSITIVE WITH RESPECT TO CATHODE	90		100		VOLTS
MAXIMUM PLATE VOLTAGE	300		330		VOLTS
MAXIMUM CATHODE CURRENT (EACH SECTION)	20		22		MA.
MAXIMUM PLATE DISSIPATION (EACH SECTION)	2.75		3.03		WATTS

CONTINUED ON FOLLOWING PAGE

TUNG-SOL

CONTINUED FROM PRECEDING PAGE

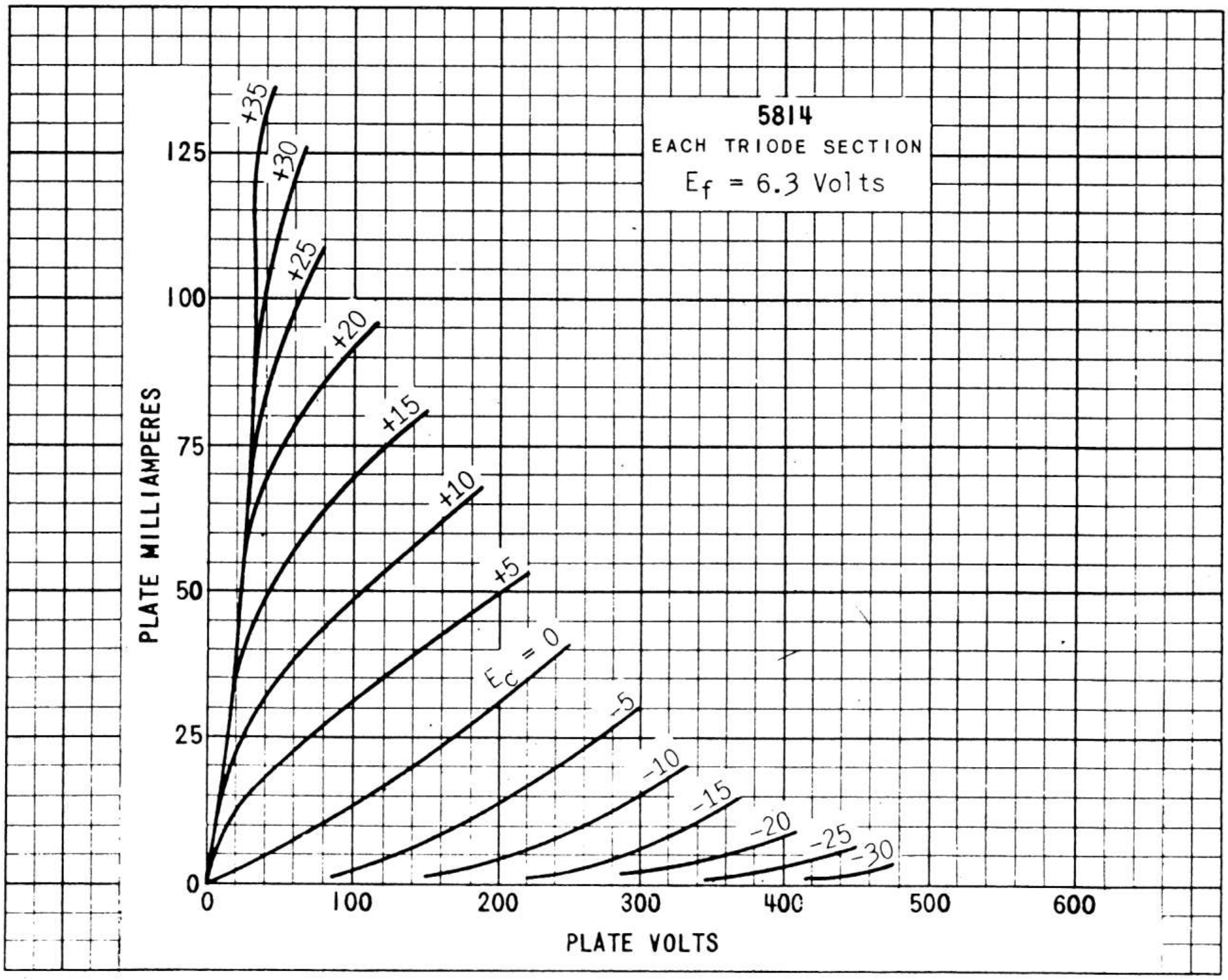
TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS

CLASS A_1 AMPLIFIER - EACH TRIODE SECTION

HEATER VOLTAGE	6.3	12.6	6.3	12.6	VOLTS
HEATER CURRENT	0.35	0.175	0.35	0.175	AMP.
PLATE VOLTAGE	100		250		VOLTS
GRID VOLTAGE[A]	0		-8.5		VOLTS
AMPLIFICATION FACTOR	19.5		17		
PLATE RESISTANCE	6250		7700		OHMS
TRANSCONDUCTANCE	3100		2200		µMHOS
PLATE CURRENT	11.8		10.5		MA.

[A] THE DC RESISTANCE IN THE GRID CIRCUIT UNDER RATED MAXIMUM CONDITIONS SHOULD NOT EXCEED 0.25 MEGOHM FOR FIXED-BIAS OPERATION AND 1.0 MEGOHM FOR CATHODE-BIAS OPERATION.

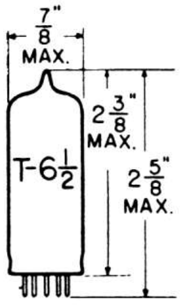
SIMILAR TYPE REFERENCE: Electrical characteristics similar to type 12AU7.



TUNG-SOL

DOUBLE TRIODE

MINIATURE TYPE



GLASS BULB

COATED UNIPOTENTIAL CATHODE

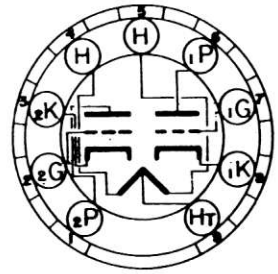
HEATER

SERIES	PARALLEL
12.6 VOLTS	6.3 VOLTS
0.3 AMP.	0.6 AMP.

AC OR DC

FOR 12.6 VOLT OPERATION APPLY HEATER VOLTAGE BETWEEN PINS #4 AND #5. FOR 6.3 VOLT OPERATION APPLY HEATER VOLTAGE BETWEEN PIN #9 AND PINS #4 AND #5 CONNECTED TOGETHER.

ANY MOUNTING POSITION



BOTTOM VIEW

MINIATURE BUTTON
9 PIN BASE

9A

THE 12BH7 COMBINES TWO INDEPENDENT SEMI-HIGH PERVEANCE, MEDIUM-MU TRIODES IN THE 9 PIN MINIATURE CONSTRUCTION. IT IS SUITABLE FOR USE AS A COMBINED VERTICAL DEFLECTION SWEEP GENERATOR AND DEFLECTION AMPLIFIER IN TELEVISION RECEIVERS USING PICTURE TUBES WITH WIDE DEFLECTION ANGLES..

DIRECT INTERELECTRODE CAPACITANCES

	TRIODE UNIT 1	TRIODE UNIT 2	
GRID TO PLATE: (G TO P)	2.6	2.6	μμf
INPUT: G TO (H+K)	3.2	3.2	μμf
OUTPUT: P TO (H+K)	0.5	0.4	μμf
COUPLING: (1P TO 2P)	0.8		μμf

RATINGS

INTERPRETED ACCORDING TO RMA STANDARD M8-210

EACH TRIODE UNIT

	CLASS A1 AMPLIFIER		VERTICAL DEFLECTION AMPLIFIER [A]		
HEATER VOLTAGE	12.6	6.3	12.6	6.3	VOLTS
MAXIMUM HEATER-CATHODE VOLTAGE:					
HEATER NEGATIVE WITH RESPECT TO CATHODE: TOTAL DC AND PEAK	200		200		VOLTS
HEATER POSITIVE WITH RESPECT TO CATHODE: DC	100		100		VOLTS
TOTAL DC AND PEAK	200		200		VOLTS
MAXIMUM PLATE VOLTAGE	300		450		VOLTS
MAXIMUM PEAK POSITIVE PLATE VOLTAGE (ABSOLUTE MAXIMUM)	---		1500		VOLTS
MAXIMUM PLATE DISSIPATION [B] EACH PLATE	3.5		3.5		WATTS
BOTH PLATES	7.0		7.0		WATTS
MAXIMUM PEAK NEGATIVE GRID VOLTAGE	---		250		VOLTS
MAXIMUM CATHODE CURRENT	20		20		MA.
MAXIMUM PEAK CATHODE CURRENT	---		70		MA.
MAXIMUM GRID CIRCUIT RESISTANCE: FIXED BIAS OPERATION	0.25		---		MEGOHMS
CATHODE BIAS OPERATION	1.0		2.2		MEGOHMS

[A] FOR OPERATION IN A 525-LINE, 30-FRAME SYSTEM AS DESCRIBED IN "STANDARDS OF GOOD ENGINEERING PRACTICE FOR TELEVISION BROADCASTING STATIONS; FEDERAL COMMUNICATIONS COMMISSION". THE DUTY CYCLE OF THE VOLTAGE PULSE NOT TO EXCEED 15% OF A SCANNING CYCLE.

[B] IN STAGES OPERATING WITH GRID-LEAK BIAS, AN ADEQUATE CATHODE BIAS RESISTOR OR OTHER SUITABLE MEANS IS REQUIRED TO PROTECT THE TUBE IN THE ABSENCE OF EXCITATION.

CONTINUED ON FOLLOWING PAGE

→ INDICATES A CHANGE OR ADDITION.

TUNG-SOL

CONTINUED FROM PRECEDING PAGE

RATINGS (CONT'D)

EACH TRIODE UNIT

	VERTICAL[C] DEFLECTION OSCILLATOR		HORIZONTAL[C] DEFLECTION OSCILLATOR		
HEATER VOLTAGE	12.6	6.3	12.6	6.3	VOLTS
MAXIMUM HEATER-CATHODE VOLTAGE:					
HEATER NEGATIVE WITH RESPECT TO CATHODE:					
TOTAL DC AND PEAK	200		200		VOLTS
HEATER POSITIVE WITH RESPECT TO CATHODE:					
DC	100		100		VOLTS
TOTAL DC AND PEAK	200		200		VOLTS
MAXIMUM DC PLATE VOLTAGE	450		450		VOLTS
MAXIMUM PLATE DISSIPATION:					
EACH PLATE	3.5		3.5		WATTS
BOTH PLATES	7.0		7.0		WATTS
MAXIMUM PEAK NEGATIVE GRID VOLTAGE	400		600		VOLTS
MAXIMUM AVERAGE CATHODE CURRENT	20		20		MA.
MAXIMUM CATHODE CURRENT	70		300		MA.
MAXIMUM GRID CIRCUIT RESISTANCE	2.2		2.2		MEGOHMS

[C] FOR OPERATION IN A 525-LINE, 30-FRAME SYSTEM AS DESCRIBED IN "STANDARDS OF GOOD ENGINEERING PRACTICE FOR TELEVISION BROADCASTING STATIONS; FEDERAL COMMUNICATIONS COMMISSION". THE DUTY

TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS

CLASS A_1 AMPLIFIER - EACH TRIODE UNIT

HEATER VOLTAGE	12.6	6.3	VOLTS
HEATER CURRENT	0.3	0.6	AMP.
PLATE VOLTAGE	250		VOLTS
GRID VOLTAGE	-10.5		VOLTS
PLATE CURRENT	11.5		MA.
AMPLIFICATION FACTOR	16.5		
PLATE RESISTANCE (APPROX.)	5 300		OHMS
TRANSCONDUCTANCE	3 100		µMHOS
PLATE CURRENT AT E_c = -14 VOLTS	4.0		MA.
GRID VOLTAGE FOR I_b = 50 µA. (APPROX.)	-23		VOLTS

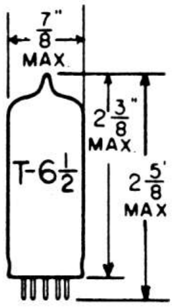
→ INDICATES A CHANGE OR ADDITION.

BB
TUNG-SOL

TWIN TRIODE

MINIATURE TYPE

COATED UNIPOTENTIAL CATHODE



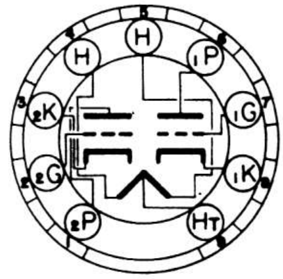
GLASS BULB

HEATER

SERIES	PARALLEL
12.6 VOLTS	6.3 VOLTS
0.3 AMP.	0.6 AMP.

AC OR DC

FOR 12.6 VOLT OPERATION APPLY HEATER VOLTAGE BETWEEN PINS #4 AND #5. FOR 6.3 VOLT OPERATION APPLY HEATER VOLTAGE BETWEEN PIN #9 AND PINS #4 AND #5 CONNECTED TOGETHER.



BOTTOM VIEW
MINIATURE BUTTON
9 PIN BASE
9A

THE 12BZ7 COMBINES TWO INDEPENDENT TRIODES IN THE 9 PIN MINIATURE CONSTRUCTION. IT IS SPECIFICALLY DESIGNED FOR TELEVISION SYNC SEPARATION AND AMPLIFICATION IN TELEVISION SETS WHERE THE PRIMARY "B" VOLTAGE IS LIMITED. IT MAY ALSO BE USED AS AN AUDIO AMPLIFIER OR IN SQUARING OR CLIPPING CIRCUITS.

DIRECT INTERELECTRODE CAPACITANCES

WITH NO EXTERNAL SHIELD

	TRIODE UNIT 1	TRIODE UNIT 2	
→ GRID TO PLATE: G TO P	2.5	2.5	μμf
INPUT: G TO (H+K)	6.5	6.5	μμf
OUTPUT: P TO (H+K)	0.7	0.55	μμf
PLATE #1 TO PLATE #2: (P_1 TO P_2)	1.3		μμf

RATINGS

INTERPRETED ACCORDING TO DESIGN CENTER SYSTEM

EACH TRIODE UNIT

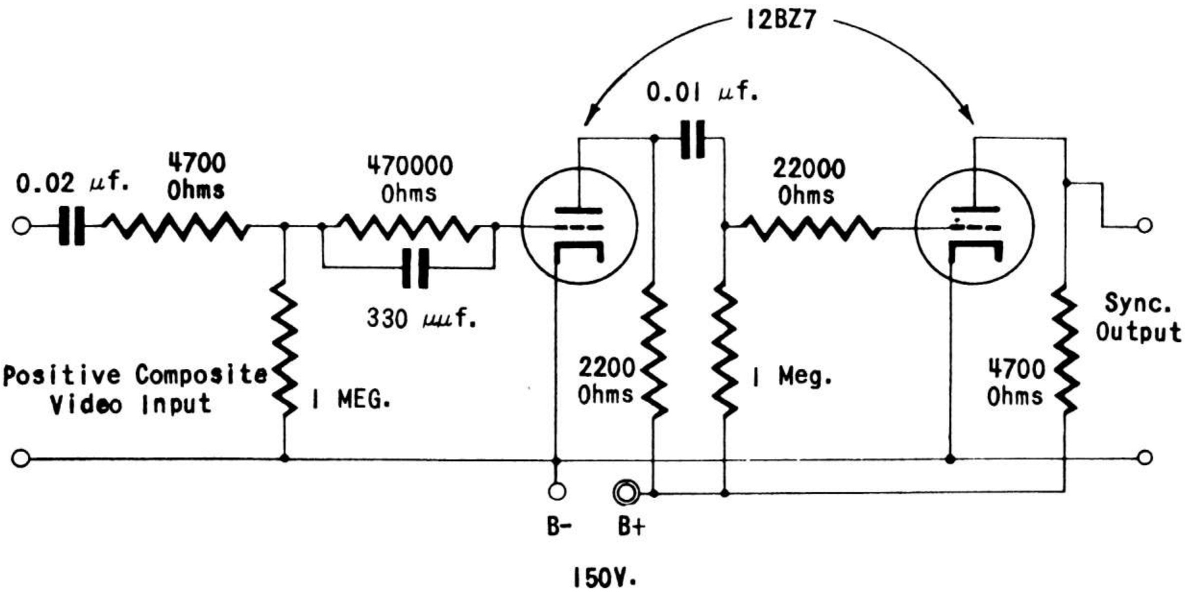
HEATER VOLTAGE	12.6	6.3	VOLTS
MAXIMUM HEATER—CAGHODE VOLTAGE	180		VOLTS
MAXIMUM PLATE VOLTAGE	300		VOLTS
MAXIMUM NEGATIVE DC GRID #1 VOLTAGE	50		VOLTS
MAXIMUM POSITIVE DC GRID #1 VOLTAGE	0		VOLTS
MAXIMUM PLATE DISSIPATION	1.5		WATTS
MAXIMUM GRID #1 CIRCUIT RESISTANCE	5		MEGOHMS

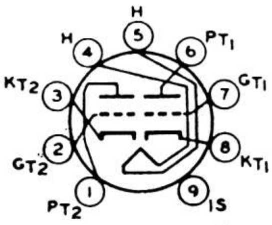
TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS

CLASS A_1 AMPLIFIER — EACH TRIODE UNIT

HEATER VOLTAGE	12.6	6.3	VOLTS
HEATER CURRENT	0.3	0.6	AMP.
PLATE VOLTAGE	250		VOLTS
GRID #1 VOLTAGE	−2		VOLTS
PLATE RESISTANCE	31 800		OHMS
AMPLIFICATION FACTOR	100		
TRANSCONDUCTANCE	3 200		μMHOS
PLATE CURRENT	2.5		MA.

→ INDICATES A CHANGE.


12BZ7
0.01 μf.
0.02 μf.
4700
Ohms
470000
Ohms
22000
Ohms
330 μμf.
Positive Composite
Video Input
1 MEG.
2200
Ohms
1 Meg.
Sync.
Output
4700
Ohms
B-
B+
150V.



9AJ

MEDIUM-MU TWIN TRIODE

6DJ8/ ECC88

INDUSTRIAL TYPE

Miniature type used as a cascode amplifier in vhf color and black-and-white television tuners. Outlines section, 6B; requires miniature 9-contact socket.

Heater Voltage (ac/dc)		6.3	volts
Heater Current		0.365	ampere

	Unit No. 1	Unit No. 2	
Heater-Cathode Voltage:			
Peak value	—	—150	volts
Average value	50	—130	volts
Direct Interelectrode Capacitances:			
Grid to Plate	1.4	1.4	pF
Grid to Cathode, Heater, and Internal Shield	3.3	—	pF
Cathode to Grid, Heater, and Internal Shield	—	6.0	pF
Plate to Cathode, Heater, and Internal Shield	1.8	—	pF
Plate to Grid, Heater, and Internal Shield	—	2.8	pF
Plate to Cathode	—	1.8	pF
Heater to Cathode	—	2.7	pF
Grid to Heater	0.13		pF
Plate of Unit No. 1 to Plate of Unit No. 2	0.045		pF
Grid of Unit No. 2 to Plate of Unit No. 1	0.005		pF

Class A_1 Amplifier (Each Unit)

MAXIMUM RATINGS (Design-Center Values)

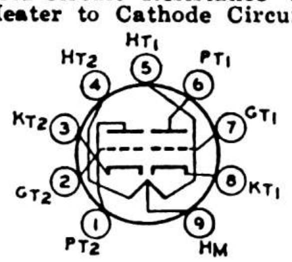
Plate Supply Voltage	130	volts
Cathode Current	25	mA
Plate Dissipation	1.8	watts
Negative Grid Voltage	50	volts
Plate Supply Voltage (cold condition)	550	volts

CHARACTERISTICS

Plate Voltage	90	volts
Grid Voltage	—1.3	volts
Amplification Factor	33	
Transconductance	12250	µmhos
Plate Current	15	mA
Equivalent Noise Resistance	300	ohms

MAXIMUM CIRCUIT VALUES

Grid-Circuit Resistance	1.0	megohm
Heater to Cathode Circuit Resistance	0.02	megohm



9A

MEDIUM-MU TWIN TRIODE

5965

INDUSTRIAL TYPE

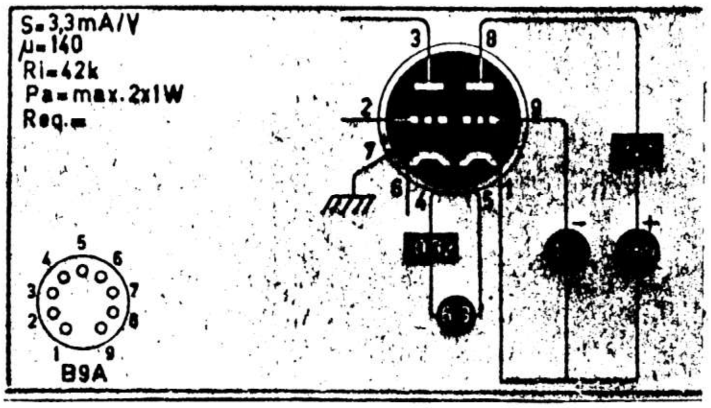
Miniature type medium-mu twin triode used for "on-off" control applications involving long periods of operation under cutoff conditions. Outlines section, 6B; requires miniature 9-contact socket.

Heater Arrangement	Series	Parallel	
Heater Voltage (ac/dc)	12.6 ±10%	6.3 ±10%	volts
Heater Current	0.225	0.45	ampere
Heater-Cathode Voltage:			
Peak value	±200 max.	±200 max.	volts
Average value	±100 max.	±100 max.	volts

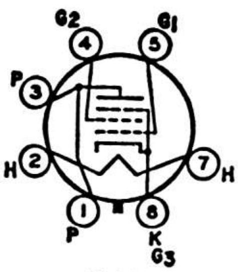
Class A_1 Amplifier (Each Unit)

CHARACTERISTICS

Plate Supply Voltage	150	volts
Cathode-Bias Resistor	220	ohms
Amplification Factor	47	
Plate Resistance	7250	ohms
Transconductance	6500	µmhos
Plate Current	8.2	mA
Grid Voltage (Approx.) for plate current of 150 µA	—5.5	volts



ECC 807
BRIMAR
and
SIEMENS
and
TELEFUNKEN



8LY

BEAM POWER TUBE 8417

Glass octal type used as output amplifier in high-fidelity, high-power sound systems. **Outlines section, 19J**; requires octal socket. This tube, like other power-handling tubes, should be adequately ventilated. **Heater:** volts (ac/dc), 6.3; amperes, 1.6; maximum heater-cathode volts, ±200 peak, 100 average.

Class A_1 Amplifier

MAXIMUM RATINGS (Design-Maximum Values)

Plate Voltage	660	volts
Grid-No.2 (Screen-Grid) Voltage	500	volts
Cathode Current	200	mA
Plate Dissipation▪	35	watts
Grid-No.2 Input	5*	watts

CHARACTERISTICS

Plate Voltage	300	volts
Grid-No.2 Voltage	300	volts
Grid-No.1 (Control-Grid) Voltage	—12	volts
Grid-No.1 Voltage for plate current of 1 mA	—37	volts
Plate Resistance	16000	ohms
Transconductance	23000	μmhos
Plate Current	100	mA
Grid-No.2 Current	5.5	mA
Triode Amplification Factor	16.5	

MAXIMUM CIRCUIT VALUES

Grid-No.1-Circuit Resistance:		
For fixed-bias operation	1	megohm
For cathode-bias operation	0.25	megohm

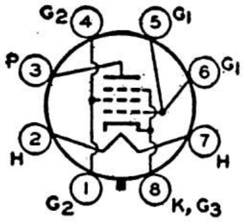
Push-Pull Class AB_1 Amplifier

MAXIMUM RATINGS (Same as for Class A_1 Amplifier)

TYPICAL OPERATION (Values are for two tubes)

Plate Supply Voltage	400	560	volts
Grid-No.2 Supply Voltage	275	300	volts
Grid-No.1 Voltage	—13	—15.5	volts
Peak AF Grid-to-Grid Voltage	24	31	volts
Zero-Signal Plate Current	150	100	mA
Maximum-Signal Plate Current	294	270	mA
Zero-Signal Grid-No.2 Current	4.4	3.4	mA
Maximum-Signal Grid-No.2 Current	34	31	mA
Effective Load (Plate-to-Plate)	2800	4200	ohms
Total Harmonic Distortion	2.5	2	per cent
Maximum Signal Power Output	65	100	watts

▪ A bias resistor or other means is required to protect the tube in absence of excitation.
* Grid-No.2 may reach 8 watts during peak levels of speech and music levels.



BEAM POWER TUBE

7027
7027-A

Glass octal types used in push-pull power amplifier circuits of high-fidelity audio equipment. Tubes provide high power sensitivity and high stability and are capable of delivering high power output at low distortion. Double base-pin connections for both grid No.1 and grid No.2 provide for flexibility of circuit arrangement and also cool operation of the grids with the result that reverse grid current is minimized. Outline 41, OUTLINES SECTION. Tubes require octal socket and may be mounted in any position. It is especially important that these tubes, like other power-handling tubes, be adequately ventilated. Type 7027 is a DISCONTINUED type listed for reference only.

HEATER VOLTAGE (AC/DC)	6.3	volts
HEATER CURRENT	0.9	ampere
DIRECT INTERELECTRODE CAPACITANCES (Approx.):		
Grid No.1 to Plate	1.5	μμf
Grid No.1 to Cathode, Heater, Grid No.2, and Grid No.3	10	μμf
Plate to Cathode, Heater, Grid No.2, and Grid No.3	7.5	μμf

CLASS A_1 AMPLIFIER

Characteristics:

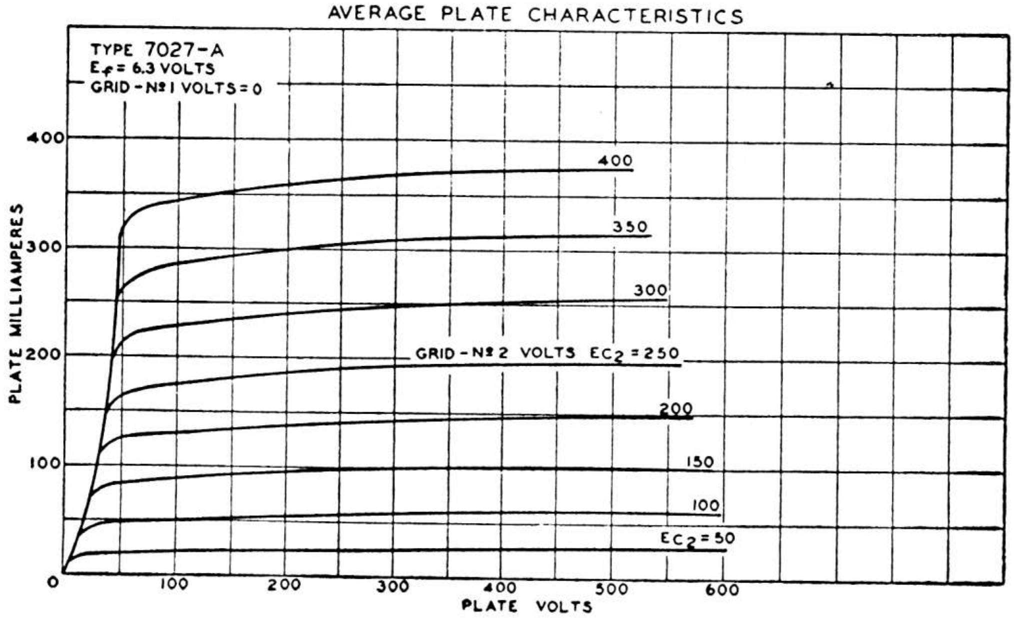
Plate Voltage	250	volts
Grid-No.2 (Screen-Grid) Voltage	250	volts
Grid-No.1 (Control-Grid) Voltage	−14	volts
Plate Resistance (Approx.)	22500	ohms
Transconductance	6000	μmhos
Plate Current	72	ma
Grid-No.2 Current	5	ma

PUSH-PULL CLASS AB_1 AMPLIFIER

Maximum Ratings for 7027-A, (*Design-Maximum Values*):

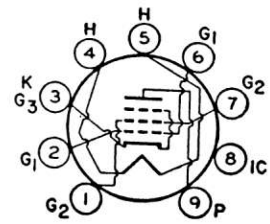
PLATE VOLTAGE	600 *max*	volts
GRID-NO.2 VOLTAGE	500 *max*	volts
PLATE DISSIPATION	35 *max*	watts
GRID-NO.2 INPUT	5 *max*	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	200 *max*	volts
Heater positive with respect to cathode	200■ *max*	volts

AVERAGE PLATE CHARACTERISTICS



7868

POWER PENTODE



Novar type used in output stages of high-fidelity audio amplifiers or radio receivers; used in applications requiring relatively large power output. Outline 53, OUTLINES SECTION, except that tube is 0.6 inch shorter in vertical dimensions. Tube requires novar nine-contact socket and may be operated in any position. It is especially important that this tube, like other power-handling tubes, be adequately ventilated.

HEATER VOLTAGE (AC/DC)	6.3	volts
HEATER CURRENT	0.8	ampere
DIRECT INTERELECTRODE CAPACITANCES (Approx.):°		
Grid No.1 to Plate	0.15	μμf
Grid No.1 to Cathode, Heater, Grid No.2, and Grid No.3	11	μμf
Plate to Cathode, Heater, Grid No.2, and Grid No.3	4.4	μμf

° Without external shield.

PUSH-PULL CLASS AB_1 AMPLIFIER

Maximum Ratings, (Same as for Class A_1 Amplifier)

Typical Operation *(Values are for two tubes)*:

	Fixed Bias				*Cathode Bias*		
Plate Supply Voltage	300	350	400	450	450	450	volts
Grid-No.2 Supply Voltage	300	350	350	350	400	400	volts
Grid-No.1 Voltage	−12.5	−15.5	−16	−16.5	−21	–	volts
Cathode-Bias Resistor (Common to both cathodes)	–	–	–	–	–	170	ohms
Peak AF Grid-No.1-to-Grid-No.1 Voltage	25	31	32	33	42	31	volts
Zero-Signal Plate Current	74	72	64	60	40	86	ma
Maximum-Signal Plate Current	116	130	135	142	145	94	ma
Zero-Signal Grid-No.2 Current	10	9.5	8	7.2	5	10	ma
Maximum-Signal Grid-No.2 Current	28	32	28	26	30	20	ma
Effective Load Resistance (Plate-to-plate)	6600	6600	6600	6600	6600	10000	ohms
Total Harmonic Distortion	5	2.5	2	2.5	5	2	per cent
Maximum-Signal Power Output	24	30	34	38	44	28	watts

PUSH-PULL CLASS AB_1 AMPLIFIER

*Grid No.2 of Each Tube Connected to Tap on Plate Winding of Output Transformer**

Maximum Ratings: (Same as for Class A_1 Amplifier)

Typical Operation *(Values are for two tubes)*:

	Fixed Bias	*Cathode Bias*	
Plate Supply Voltage	400	425	volts
Grid-No.2 Supply Voltage	*	*	volts
Grid-No.1 Voltage	−20.5	–	volts
Cathode-Bias Resistor (Common to both cathodes)	–	185	ohms
Peak AF Grid-No.1-to-Grid-No.1 Voltage	41	42	volts
Zero-Signal Plate Current	60	88	ma
Maximum-Signal Plate Current	115	100	ma
Zero-Signal Grid-No.2 Current	8	12	ma
Maximum-Signal Grid-No.2 Current	18	16	ma
Effective Load Resistance (Plate-to-plate)	6600	6600	ohms
Total Harmonic Distortion	2.5	3.5	per cent
Maximum-Signal Power Output	23	21	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance:		
For fixed-bias operation	0.3 *max*	megohm
For cathode-bias operation	1 *max*	megohm

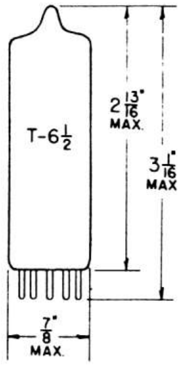
■ In push-pull circuits where the grid No.2 of each tube is connected to a tap on the plate winding of the output transformer, this maximum rating is 440 volts.

• Grid No.2 input may reach 6 watts during peak levels of speech and music signals.

□ The dc component must not exceed 100 volts.

* Grid No.2 supply voltage is obtained from taps on the primary winding of the output transformer. The taps are located on each side of the center tap (B+) so as to apply 50 per cent of the plate signal voltage to the grid No.2 of each output tube.

PENTODE



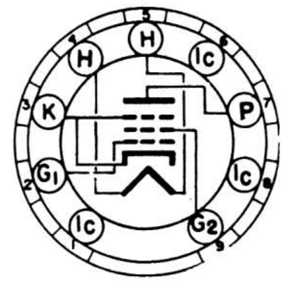
GLASS BULB

COATED UNIPOTENTIAL CATHODE

HEATER

6.3 VOLTS 0.76 AMP.

ANY MOUNTING POSITION



BOTTOM VIEW

9 PIN BASE

9CV

THE 6BQ5 IS AN OUTPUT PENTODE DESIGNED FOR APPLICATION IN MEDIUM POWER HI-FI AMPLIFIERS. A PAIR OF TUBES IN CLASS AB, PUSH-PULL CONVENTIONAL OPERATION YIELDS AN OUTPUT OF UP TO 17 WATTS AT 4% DISTORTION (WITHOUT FEEDBACK). IN SINGLE-ENDED OPERATION A POWER OUTPUT OF 5.7 WATTS CAN BE OBTAINED.

DIRECT INTERELECTRODE CAPACITANCES

GRID #1 TO ALL OTHER ELEMENTS	10.8	μμf
PLATE TO ALL OTHER ELEMENTS	6.5	μμf
PLATE TO GRID #1 (MAX.)	0.5	μμf
GRID #1 TO HEATER (MAX.)	0.25	μμf

RATINGS

INTERPRETED ACCORDING TO DESIGN CENTER SYSTEM

HEATER VOLTAGE	6.3	VOLTS
MAXIMUM PLATE VOLTAGE[A]	300	VOLTS
MAXIMUM PLATE VOLTAGE WITHOUT PLATE CURRENT	550	VOLTS
MAXIMUM PLATE DISSIPATION[A]	12	WATTS
MAXIMUM GRID #2 VOLTAGE [A]	300	VOLTS
MAXIMUM GRID #2 VOLTAGE WITHOUT CURRENT	550	VOLTS
MAXIMUM GRID #2 DISSIPATION	2	WATTS
MAXIMUM GRID #2 PEAK DISSIPATION	4	WATTS
MAXIMUM NEGATIVE GRID #1 VOLTAGE	100	VOLTS
MAXIMUM GRID CURRENT STARTING POINT		
MAXIMUM GRID #1 VOLTAGE WHEN GRID #1 CURRENT IS 0.3 μAMP.	-1.3	VOLTS
MAXIMUM GRID #1 CIRCUIT RESISTANCE WITH AUTOMATIC BIAS	1	MEGOHM
MAXIMUM GRID #1 CIRCUIT RESISTANCE WITH FIXED BIAS	0.3	MEGOHM
MAXIMUM CATHODE CURRENT	65	MA.
MAXIMUM VOLTAGE BETWEEN HEATER AND CATHODE	100	VOLTS

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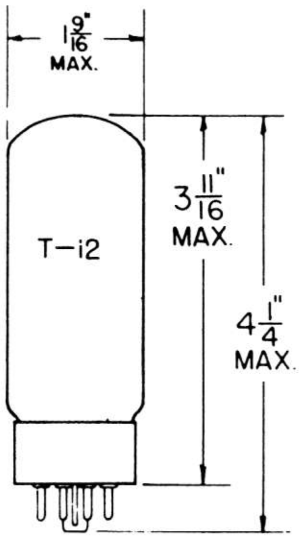
PENTODE



GLASS BULB

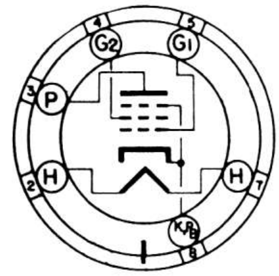
COATED UNIPOTENTIAL CATHODE

HEATER

6.3 VOLTS 0.9 AMP.

AC OR DC

ANY MOUNTING POSITION



BOTTOM VIEW

SHORT MEDIUM SHELL
6 PIN OCTAL

SHORT MEDIUM SHELL
7 PIN OCTAL

MEDIUM SHELL
7 PIN OCTAL

7AC

THE 6L6GC IS A BEAM-POWER PENTODE PRIMARILY DESIGNED FOR USE IN AUDIO-FREQUENCY POWER AMPLIFIER APPLICATIONS. THE 6L6GC HAS THE SAME CHARACTERISTICS AS THE 6L6GB. HOWEVER, THE HIGHER POWER RATINGS OF THE 6L6GC ARE ADVANTAGEOUS WHERE GREATER POWER-HANDLING CAPABILITY IS REQUIRED.

DIRECT INTERELECTRODE CAPACITANCES -approx.

WITHOUT EXTERNAL SHIELD

GRID #1 TO PLATE	0.6	μμf
INPUT	10	μμf
OUTPUT	6.5	μμf

RATINGS

INTERPRETED ACCORDING TO DESIGN MAXIMUM SYSTEM

	TRIODE[B] CONNECTION	PENTODE CONNECTION	
HEATER VOLTAGE	6.3	6.3	VOLTS
MAXIMUM PLATE VOLTAGE	450	500	VOLTS
MAXIMUM SCREEN VOLTAGE		450[A]	
MAXIMUM PLATE DISSIPATION	30	30	WATTS
MAXIMUM SCREEN DISSIPATION		5.0	WATTS
MAXIMUM HEATER-CATHODE VOLTAGE:			
HEATER POSITIVE WITH RESPECT TO CATHODE	200	200	VOLTS
HEATER NEGATIVE WITH RESPECT TO CATHODE	200	200	VOLTS
MAXIMUM GRID #1 CIRCUIT RESISTANCE:			
WITH FIXED BIAS	0.1	0.1	MEG.
WITH CATHODE BIAS	0.5	0.5	MEG.

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TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS

CLASS A_1 AMPLIFIER - TRIODE CONNECTION[B]

HEATER VOLTAGE	6.3	VOLTS
HEATER CURRENT	0.9	AMP.
PLATE VOLTAGE	250	VOLTS
GRID #1 VOLTAGE	-20	VOLTS
PEAK AF GRID #1 VOLTAGE	20	VOLTS
AMPLIFICATION FACTOR	8	
PLATE RESISTANCE, APPROX.	1700	OHMS
TRANSCONDUCTANCE	4700	μMHOS
ZERO-SIGNAL PLATE CURRENT	40	MA.
MAXIMUM-SIGNAL PLATE CURRENT	44	MA.
LOAD RESISTANCE	5000	OHMS
TOTAL HARMONIC DISTORTION, APPROX.	5	PERCENT
MAXIMUM-SIGNAL POWER OUTPUT	1.4	WATTS

CLASS A_1 AMPLIFIER - PENTODE CONNECTION

PLATE VOLTAGE	250	300	350	VOLTS
SCREEN VOLTAGE	250	200	250	VOLTS
GRID #1 VOLTAGE	-14	-12.5	-18	VOLTS
PEAK AF GRID #1 VOLTAGE	14	12.5	18	VOLTS
PLATE RESISTANCE, APPROX.	22500	35000	33000	OHMS
TRANSCONDUCTANCE	6000	5300	5200	μMHOS
ZERO-SIGNAL PLATE CURRENT	72	48	54	MA.
MAXIMUM-SIGNAL PLATE CURRENT	79	55	66	MA.
ZERO-SIGNAL SCREEN CURRENT	5.0	2.5	2.5	MA.
MAXIMUM-SIGNAL SCREEN CURRENT	7.3	4.7	7.0	MA.
LOAD RESISTANCE	2500	4500	4200	OHMS
TOTAL HARMONIC DISTORTION, APPROX.	10	11	15	PERCENT
MAXIMUM-SIGNAL POWER OUTPUT	6.5	6.5	10.8	WATTS

PUSH-PULL CLASS A_1 AMPLIFIER - VALUES FOR TWO TUBES

PLATE VOLTAGE	250	270	VOLTS
SCREEN VOLTAGE	250	270	VOLTS
GRID #1 VOLTAGE	-16	-17.5	VOLTS
PEAK AF GRID TO GRID VOLTAGE	32	35	VOLTS
ZERO-SIGNAL PLATE CURRENT	120	134	MA.
MAXIMUM SIGNAL PLATE CURRENT	140	155	MA.
ZERO-SIGNAL SCREEN CURRENT	10	11	MA.
MAXIMUM-SIGNAL SCREEN CURRENT	16	17	MA.
EFFECTIVE LOAD RESISTANCE, PLATE-TO-PLATE	5000	5000	OHMS
TOTAL HARMONIC DISTORTION	2	2	PERCENT
MAXIMUM SIGNAL POWER OUTPUT	14.5	17.5	WATTS

PUSH-PULL CLASS AB_1 AMPLIFIER - VALUES FOR TWO TUBES

PLATE VOLTAGE	360	360	450	VOLTS
SCREEN VOLTAGE	270	270	400	VOLTS
GRID #1 VOLTAGE	-22.5	-22.5	-37	VOLTS
PEAK AF GRID-TO-GRID VOLTAGE	45	45	70	VOLTS

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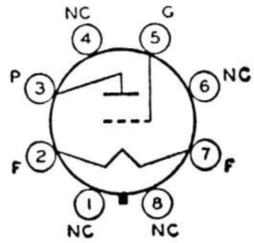
VTL

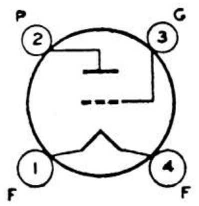
POWER TRIODE



Glass octal type used in output stage of radio receivers and amplifiers. Outline 50, OUTLINES SECTION. Tube requires octal socket. For typical operation as a single-tube class A amplifier, refer to type 2A3. Filament volts (ac/dc), 6.3; amperes, 1.0. Maximum ratings as push-pull class AB_1 amplifier: plate volts, 325; plate dissipation, 15 watts. Type 6B4-G is a DISCONTINUED type listed for reference only.

6B4-G

POWER TRIODE



Glass type used in output stage of radio receivers and amplifiers. As a class A_1 power amplifier, the 2A3 is usable either singly or in push-pull combination.

2A3

FILAMENT VOLTAGE (AC/DC)	2.5	volts
FILAMENT CURRENT	2.5	amperes
DIRECT INTERELECTRODE CAPACITANCES (Approx.):		
Grid to Plate	16.5	μμf
Grid to Filament	7.5	μμf
Plate to Filament	5.5	μμf

CLASS A_1 AMPLIFIER

Maximum Ratings:

PLATE VOLTAGE	300 *max*	volts
PLATE DISSIPATION	15 *max*	watts

Typical Operation:

Plate Voltage	250	volts
Grid Voltage*#	-45	volts
Plate Current	60	ma
Amplification Factor	4.2	
Plate Resistance	800	ohms
Transconductance	5250	μmhos
Load Resistance	2500	ohms
Second Harmonic Distortion	5	per cent
Power Output	3.5	watts

PUSH-PULL CLASS AB_1 AMPLIFIER

Maximum Ratings:

PLATE VOLTAGE	300 *max*	volts
PLATE DISSIPATION	15 *max*	watts

Typical Operation (*Values Are For Two Tubes*):	*Fixed Bias*	*Cathode Bias*	
Plate Supply Voltage	300	300	volts
Grid Voltage	-62*	–	volts
Cathode-Bias Resistor	–	780	ohms
Peak AF Grid-to-Grid Voltage	124	156	volts
Zero-Signal Plate Current	80	80	ma
Maximum-Signal Plate Current	147	100	ma
Effective Load Resistance (Plate-to-plate)	3000	5000	ohms
Total Harmonic Distortion	2.5	5.0	per cent
Power Output	15	10	watts

Maximum Circuit Values:

Grid-Circuit Resistance:		
For fixed-bias operation	0.05 *max*	megohm
For cathode-bias operation	0.5 *max*	megohm

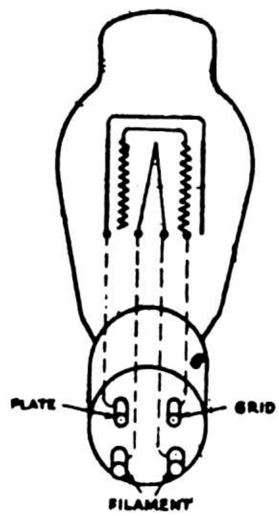
* Grid voltage referred to mid-point of filament transformer.

When a single 2A3 is operated cathode-biased, the cathode-biasing resistor value should be 750 ohms.

IMPORTANT—READ CAREFULLY

Western Electric

300B Vacuum Tube



Classification

The 300B vacuum tube is an audio-frequency power triode intended for applications where outputs of 10 watts or less are required, and where it is desirable to operate with relatively low plate voltages.

Base, Socket and Mounting

This tube employs a standard four-pin thrust type base suitable for use in a Western Electric 143B or similar socket. The base is equipped with a bayonet pin so that the tube may also be used in a Western Electric 100M or similar socket.

It may be mounted in either a vertical or horizontal position although the vertical position is preferable. If mounted in the horizontal position the arrangement should be such that the plane through the legs of the filament is vertical.

Filament Rating

Filament voltage	5.0 volts, A.C. or D.C.
Nominal filament current	1.2 amperes

The filament of this tube is designed to operate on a voltage basis and it should be operated as near the rated voltage as possible.

Operating Conditions

The tube should be operated at such plate and grid voltages that the plate current does not exceed 100 milliamperes.

Recommended and maximum operating conditions are given in the table below.

Table

	Plate Voltage	Grid Voltage*	Nominal Plate Current Milliamperes
Recommended Conditions	200	−33	77
		−45	20
	250	−46	74
		−57	22
	300	−60	68
		−70	23
	400	−86	68
		−98	19
Maximum Conditions	450	−100	60

* These voltages apply for operation with A.C. on the filament. With D.C. voltage applied to the filament equivalent operating conditions will be obtained with approximately 3.5 volts less grid bias measured from the negative end of the filament.

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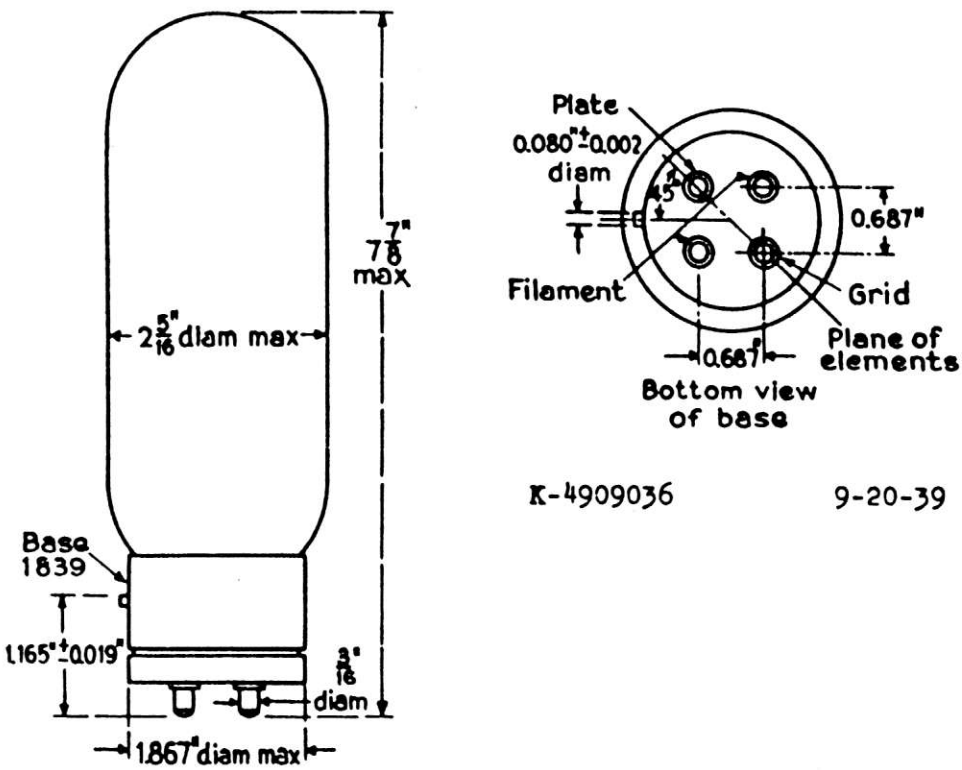
GENERAL ELECTRIC

Transmitting Tube GL-211 – Instructions

U. S. Army Signal Corps Tube Type VT-4-C



K-4909036 9-20-39

The GL-211 is a general-purpose three-electrode vacuum tube and may be used as a Class A, B, or C amplifier.

Technical Information

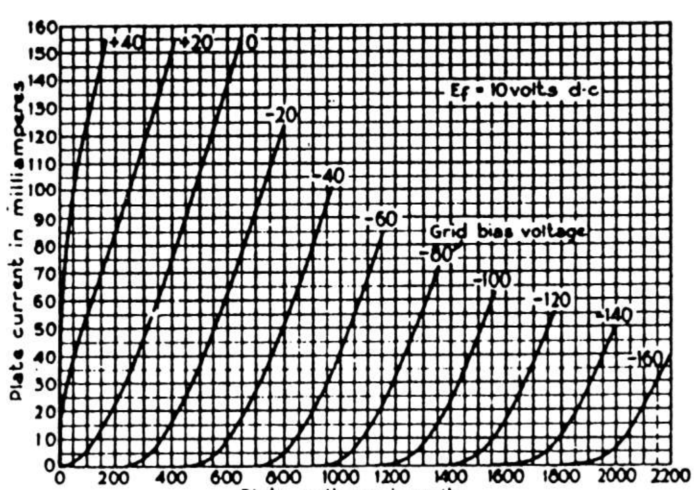
GENERAL CHARACTERISTICS:

Filament Voltage, volts	10
Filament Current, amperes	3.25
Amplification Factor	12
Grid-plate Transconductance, mmhos, I_b = 60 ma	3600
Direct Interelectrode Capacitances, μμf	
Grid-plate	14.5
Input	6
Output	5.5
Base	Jumbo 4- Large Pin
Net Weight, oz approx	8
Shipping Weight, lb approx	4

KKK VTL

	Typical Operation			Max Ratings
CLASS A A-F AMPLIFIER AND MODULATOR:				
D-c Plate Voltage, v	750	1000	1250	1250
Plate Dissipation, w				75
D-c Grid Voltages, v	-46	-61	-80	
Peak Grid Swing, approx volts	41	56	75	
D-c Plate Current, ma	34	53	60	
Plate Resistance, ohms	4400	3800	3600	
Load Resistance, ohms	8800	7600	9200	
Plate Power Output (5% Second Harmonic), w	5.6	12	19.7	
CLASS B A-F POWER AMPLIFIER (TWO TUBES):				
D-c Plate Voltage, v		1000	1250	1250
Max Signal Plate Current(per tube)§,amp				0.175
D-c Max Signal Plate Input (per tube)§,w				220
Plate Dissipation (per tube)§, w				100
D-c Grid Voltage, v		-72	-95	
Peak A-f Grid Input Voltage, v		380	410	
Zero Signal Plate Current, ma		20	20	
Max Signal Plate Current, ma		320	320	
Max Signal Driving Power, approx w		7.5	8	
Effective Load (plate to plate), ohms		6900	9000	
Max Signal Plate Power Output, watts		200	260	

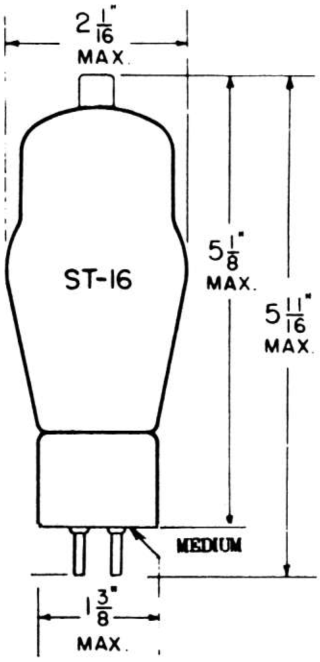
§ Averaged over any audio-frequency cycle



Average Plate Characteristics

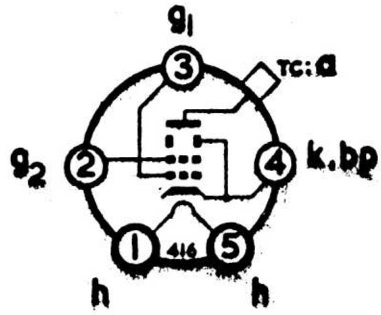
TUNG-SOL

807



COATED UNIPOTENTIAL CATHODE

OUTPUT BEAM TETRODE



UX5 Base

GENERAL

This beam tetrode is for use in the output stages of large audio equipment. The valve may be used as R.F. amplifier or frequency multiplier in transmitters. Above 60 MHz the ratings must be reduced and at 120 MHz the ratings must not exceed 50 per cent of the maximum.

Heater Voltage	V_h	6·3	V
Heater Current	I_h	0·9	A

ABSOLUTE MAXIMUM RATINGS

Maximum Anode Dissipation	$p_{a(max)}$	25	W
Maximum Screen Grid Dissipation	$p_{g2(max)}$	3·5	W
Maximum Anode Voltage	$V_{a(max)}$	600	V
Maximum Screen Grid Voltage	$V_{g2(max)}$	300	V

OPERATING CHARACTERISTICS—Class 'A'

Anode Voltage	V_a	300	500	V
Screen Grid Voltage	V_{g2}	250	200	V
Control Grid Voltage	V_{g1}	−12·5	−14·5	V
Anode Current	I_a	83	50	mA
Screen Grid Current	I_{g2}	8·0	1·6	mA
Cathode Bias Resistance	R_k	140	280	Ω
Valve Anode Resistance ($\delta v_a/\delta i_a$)	r_a	24	39	kΩ
Mutual Conductance	g_m	6·5	5·7	mA/V
Optimum Load Resistance	R_L	3·0	6·0	kΩ
Power Output	P_{out}	6·4	11·5	W
Harmonic Distortion	D	6·0	12	%

TYPICAL OPERATION—Push Pull (2 Valves)

		Class AB_1		Class AB_2†	
Anode Voltage	V_a	500	600	600	V
Screen Grid Voltage	V_{g2}	300	300	300	V
Control Grid Voltage	V_{g1}	—	−27·5	−30	V
Quiescent Anode Current	$I_{a(o)}$	100	80	60	mA
Anode Current (maximum signal)	$I_{a(max\ sig)}$	119	150	200	mA
Quiescent Screen Grid Current	$I_{g2(o)}$	2·5	1·5	1·5	mA
Screen Grid Current (maximum signal)	$I_{g2(max\ sig)}$	16·5	17·5	21	mA
Cathode Bias Resistance	R_k	270	—	—	Ω
Peak Grid to Grid Input Voltage	$V_{g-g(pk)}$	72	59	78	V
Optimum Load Resistance (Anode to Anode)	R_{a-a}	9·0	10	6·4	kΩ
Power Output	P_{out}	32·5	47·5	80	W
Harmonic Distortion	D	2·7	2·2	3·5	%

845

MODULATOR, A-F POWER AMPLIFIER

Filament	Thoriated Tungsten	
Voltage	10	a-c or d-c volts
Current	3.25	amp.
Amplification Factor	5.3	
Direct Interelectrode Capacitances:		
Grid to Plate	13.5	μμf
Grid to Filament	6	μμf
Plate to Filament	6.5	μμf
Maximum Overall Length		7-7/8"
Maximum Diameter		2-5/16"
Bulb		T-18
Base		Jumbo 4-Large Pin
RCA Socket		Type UT-541 ←

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

A-F POWER AMPLIFIER & MODULATOR - Class A_1

D-C Plate Voltage			1250 max.	volts
Plate Dissipation			100 max.	watts ←
Typical Operation: ←				
D-C Plate Voltage	750	1000	1250	volts
D-C Grid Voltage*	-98	-145	-195	volts
Peak A-F Grid Voltage	93	140	190	volts
D-C Plate Current	95	90	80	ma.
Transconductance	3100	3100	3100	μmhos
Plate Resistance	1700	1700	1700	ohms
Load Resistance	3400	6000	11000	ohms
U.P.O. (5% second harmonic)	15	24	30	watts

NOTE: In cases where the input circuit to the 845 is resistance coupled, the resistance in the grid circuit should not exceed 0.5 megohm when cathode bias is used. Without cathode bias, the d-c resistance in the grid-coupling circuit should not exceed 0.1 megohm.

A-F POWER AMPLIFIER & MODULATOR - Class AB_1 ←

D-C Plate Voltage		1250 max.	volts
D-C Grid Voltage		-400 max.	volts
D-C Plate Current		120 max.	ma.
Plate Input		150 max.	watts
Plate Dissipation		100 max.	watts
Typical Operation:			
Unless otherwise specified, values are for 2 tubes			
D-C Plate Voltage	1000	1250	volts
D-C Grid Voltage*	-175	-225	volts
Peak A-F Grid-to-Grid Voltage	340	440	volts
Zero-Signal D-C Plate Current	40	40	ma.
Max.-Signal D-C Plate Current	230	240	ma.
Load Resistance (per tube)	1150	1650	ohms
Effective Load Res. (plate to plate)	4600	6600	ohms
Max.-Signal Power Output	75	115	approx. watts

* With a-c filament supply.

OUTLINE DIMENSIONS, TUBE SYMBOL, and SOCKET CONNECTIONS for the 845 are the same as for the 211.

← Indicates a change.

INSTALLATION AND APPLICATION

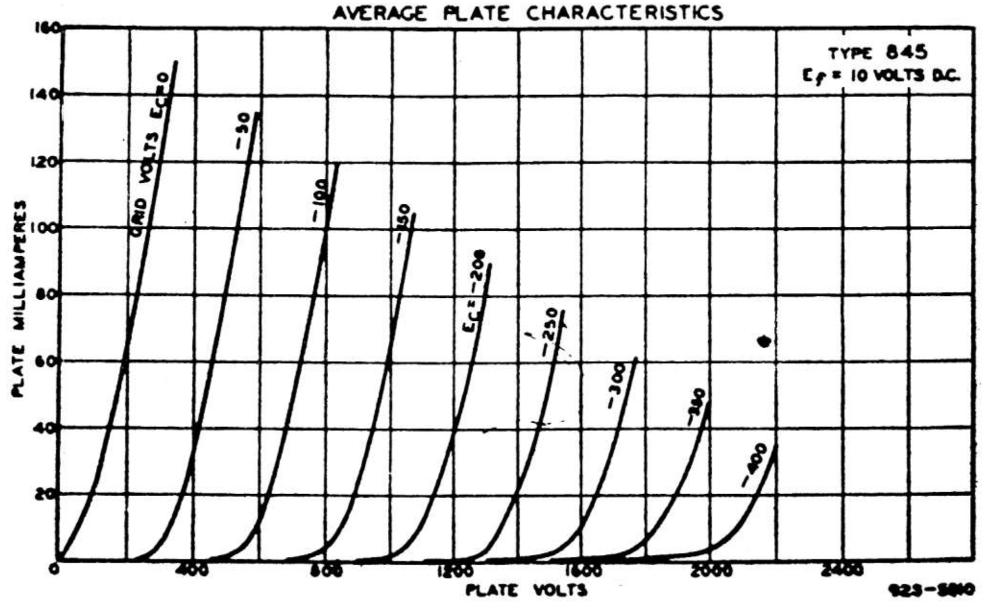
The **base** pins of the RCA-845 fit the standard four-contact socket, such as the RCA type UT-541A. The socket should be installed so that the tube will operate in a vertical position with the base down.

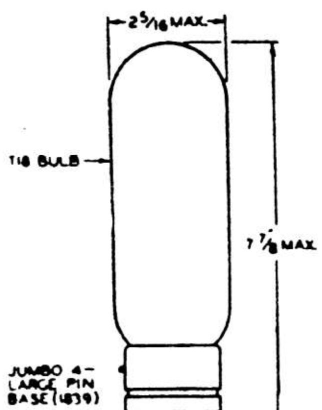
In **cases** where the input circuit of the 845 is resistance-coupled or impedance-coupled, the resistance in the grid circuit should not be made too high. A resistance value of 0.5 megohm is recommended when one 845 is used with cathode bias; without cathode bias, the grid resistance should not exceed 0.1 megohm.

In **push-pull class AB amplifier** service, each 845 should be provided with individual adjustment of grid-bias voltage. Each bias supply should be by-passed by a suitable condenser to minimize degenerative effects.

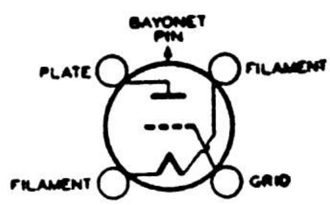
The **plate** of the 845 shows no color at the maximum plate-dissipation rating for each class of service.

For additional information, see chapters on INSTALLATION and APPLICATION.



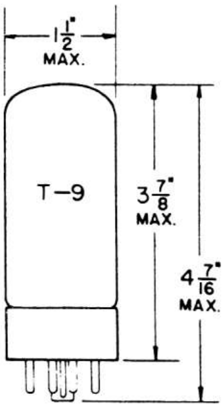


Top View of Socket Connections



PENTODE

MINIATURE TYPE



GLASS BULB

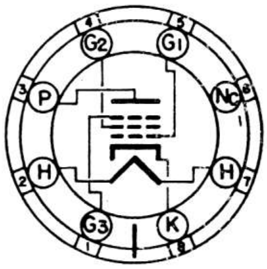
COATED UNIPOTENTIAL CATHODE

HEATER

6.3 VOLTS 1.5 AMPS.

AC OR DC

ANY MOUNTING POSITION



BOTTOM VIEW
8 PIN OCTAL

8ET

THE 6CA7 IS A POWER PENTODE OF THE GLASS OCTAL TYPE. THIS TUBE IS SUITABLE FOR ALL APPLICATIONS WHICH REQUIRE PEAK POWERS OF UP TO 11 WATTS FROM A SINGLE TUBE OR UP TO 100 WATTS FROM TWO TUBES IN THE NORMAL PUSH-PULL ARRANGEMENT. IT IS EQUALLY SUITABLE FOR DOMESTIC AMPLIFIERS AND PUBLIC ADDRESS EQUIPMENT.

DIRECT INTERELECTRODE CAPACITANCES

GRID #1 TO ALL OTHER ELEMENTS EXCEPT PLATE	15.5	μμf
PLATE TO ALL OTHER ELEMENTS EXCEPT GRID #1	7.2	μμf
PLATE TO GRID #1 (MAX.)	1.0	μμf
GRID #1 TO HEATER (MAX.)	1.0	μμf
HEATER TO CATHODE	11	μμf

RATINGS

INTERPRETED ACCORDING TO DESIGN CENTER SYSTEM

HEATER VOLTAGE	6.3	VOLTS
MAXIMUM PLATE VOLTAGE	800	VOLTS
MAXIMUM PLATE VOLTAGE WITHOUT PLATE CURRENT	2000	VOLTS
MAXIMUM PLATE DISSIPATION	25	WATTS
MAXIMUM PLATE DISSIPATION WITHOUT INPUT SIGNAL	27.5	WATTS
MAXIMUM GRID #2 VOLTAGE	425	VOLTS
MAXIMUM GRID #2 VOLTAGE WITHOUT PLATE CURRENT	800	VOLTS
MAXIMUM GRID #2 DISSIPATION	8	WATTS
CATHODE CURRENT	150	MAMPS
MAXIMUM GRID CURRENT STARTING POINT. GRID #1 VOLTAGE WHEN GRID #1 CURRENT IS 0.3μAMP	−1.3	VOLTS
MAXIMUM GRID #1 CIRCUIT RESISTANCE (CLASS A & AB)	0.7	MEGOHM
MAXIMUM GRID #1 CIRCUIT RESISTANCE (CLASS B)	0.5	MEGOHM
MAXIMUM EXTERNAL RESISTANCE BETWEEN HEATER AND CATHODE	20000	OHMS
MAXIMUM VOLTAGE BETWEEN HEATER AND CATHODE	100	VOLTS

CONTINUED ON FOLLOWING PAGE

6CA7 - EL34

TENTATIVE DATA

TUNG-SOL

CONTINUED FROM PRECEDING PAGE

TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS

CLASS A - ONE TUBE

HEATER VOLTAGE	6.3		VOLTS
HEATER CURRENT	1.5		AMPS.
SUPPLY VOLTAGE	265	265	VOLTS
PLATE VOLTAGE	250	250	VOLTS
GRID #2 SERIES RESISTOR	2000	0	OHMS
GRID #3 VOLTAGE	0	0	VOLT
GRID #1 BIAS	−14.5	−13.5	VOLTS
PLATE CURRENT	70	100	MAMPS
GRID #2 CURRENT	10	15	MAMPS
TRANSCONDUCTANCE	9000	11000	μMHOS
AMPLIFICATION FACTOR OF GRID #2 WITH RESPECT TO GRID #1	11	11	
PLATE RESISTANCE	18000	15000	OHMS
PLATE LOAD RESISTANCE	3000	2000	OHMS
INPUT VOLTAGE (RMS)	9.3	8.7	VOLTS
MAX. SIGNAL POWER OUTPUT	8	11	WATTS
TOTAL HARMONIC DISTORTION	10	10	PERCENTS
INPUT VOLTAGE FOR POWER OUTPUT OF 50 MWATTS (RMS)	0.65	0.5	VOLT

CLASS B - TWO TUBES

SUPPLY VOLTAGE 425 VOLTS

COMMON GRID #2 RESISTOR		1000		OHMS
GRID #1 BIAS		−38		VOLTS
GRID #3 VOLTAGE		0		VOLT
INPUT BOLTAGE (RMS)	0	27	27	VOLTS
LOAD RESISTANCE, PLATE TO PLATE	–	3400	4000	OHMS
SUPPLY VOLTAGE	425	425	400	VOLTS
PLATE VOLTAGE	420	400	375	VOLTS
PLATE CURRENT	2X30	2X120	2X100	MAMPS
GRID #2 CURRENT	2X4.4	2X25	2X25	MAMPS
MAX. SIGNAL POWER OUTPUT	0	55	45	WATTS
TOTAL HARMONIC DISTORTION	–	5	6	PERCENTS

CLASS B - TWO TUBES

SUPPLY BOLTAGE 375 VOLTS

COMMON GRID #2 RESISTOR		470		OHMS
GRID #1 BIAS		−32		VOLTS
GRID #3 VOLTAGE		0		VOLT
INPUT VOLTAGE (RMS)	0	22.7	22.7	VOLTS
LOAD RESISTANCE, PLATE TO PLATE	–	2800	3800	OHMS
SUPPLY VOLTAGE	375	375	350	VOLTS
PLATE VOLTAGE	370	350	325	VOLTS
PLATE CURRENT	2X35	2X120	2X93	MAMPS
GRID #2 CURRENT	2X4.7	2X25	2X25	MAMPS
MAX. SIGNAL POWER OUTPUT	0	44	36	WATTS
TOTAL HARMOINIC DISTORTION	–	5	6	PERCENTS

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TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS
(CONT'D.)

CLASS B - TWO TUBES

SUPPLY VOLTAGE 500/400 VOLTS

COMMON GRID #2 RESISTOR		750		OHMS
GRID #1 BIAS		−36		VOLTS
GRID #3 VOLTAGE		0		VOLT
INPUT VOLTAGE (RMS)	0	25.8	25.8	VOLTS
LOAD RESISTANCE, PLATE TO PLATE	–	4000	5000	OHMS
PLATE SUPPLY VOLTAGE	500	500	475	VOLTS
PLATE VOLTAGE	495	475	450	VOLTS
GRID #2 SUPPLY VOLTAGE	400	400	375	VOLTS
PLATE CURRENT	2X30	2X125	2X102	MAMPS
GRID #2 CURRENT	2X4	2X25	2X25	MAMPS
MAX. SIGNAL POWER OUTPUT	0	70	58	WATTS
TOTAL HARMONIC DISTORTION	–	5	6	PERCENTS

CLASS B - TWO TUBES

SUPPLY VOLTAGE 800/400 VOLTS

COMMON GRID #2 RESISTOR		750		OHMS
GRID #1 BIAS		−39		VOLTS
GRID #3 VOLTAGE		0		VOLT
INPUT VOLTAGE (RMS)	0	23.4	23.4	VOLTS
LOAD RESISTANCE, PLATE TO PLATE	–	11000	11000	OHMS
PLATE SUPPLY VOLTAGE	800	800	750	VOLTS
PLATE VOLTAGE	795	775	725	VOLTS
GRID #2 SUPPLY VOLTAGE	400	400	375	VOLTS
PLATE CURRENT	2X25	2X91	2X84	MAMPS
GRID #2 CURRENT	2X3	2X19	2X19	MAMPS
MAX. SIGNAL POWER OUTPUT	0	100	90	WATTS
TOTAL HARMONIC DISTORTION	–	5	6	PERCENTS

CLASS AB - TWO TUBES

SUPPLY VOLTAGE 375 VOLTS

LOAD RESISTANCE, PLATE TO PLATE		3400		OHMS
COMMON GRID #2 RESISTOR		470		OHMS
CATHODE RESISTOR		130		OHMS
GRID #3 VOLTAGE		0		VOLT
INPUT VOLTAGE (RMS)	0		21	VOLTS
SUPPLY VOLTAGE	375		375	VOLTS
PLATE VOLTAGE +VOLTAGE ACROSS CATHODE RESISTOR	355		350	VOLTS
PLATE CURRENT	2X75		2X95	MAMPS
GRID #2 CURRENT	2X11.5		2X22.5	MAMPS
MAX. SIGNAL POWER OUTPUT	0		35	WATTS
TOTAL HARMONIC DISTORTION	–		5	PERCENTS

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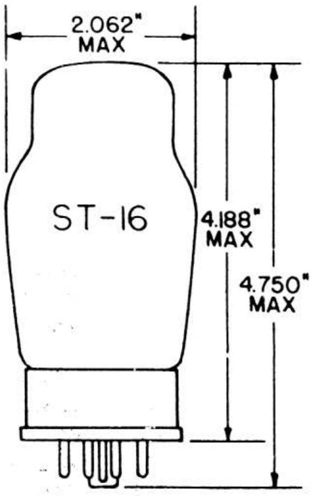
TUNG-SOL

PENTODE

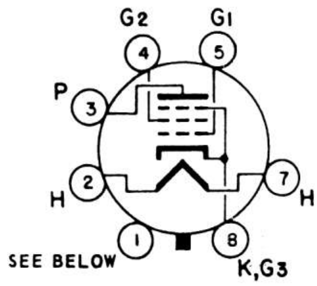


GLASS BULB
LARGE WAFER OCTAL ←
WITH BARRIERS
7 PIN LOW LOSS B7-99

FOR
AUDIO SERVICE APPLICATIONS

COATED UNIPOTENTIAL CATHODE

ANY MOUNTING POSITION



BOTTOM VIEW

BASING DIAGRAM
JEDEC 7AC

PIN 1 - NO CONNECTION
OR BASE SHELL

THE 6550 IS A BEAM PENTODE POWER AMPLIFIER PRIMARILY DESIGNED FOR AUDIO SERVICE. IT CARRIES A 42 WATT PLATE DISSIPATION RATING WHICH PROVIDES FOR PUSH-PULL AMPLIFIER DESIGNS UP TO 100 WATTS OUTPUT. CONSTRUCTION FEATURES PROVIDE FOR RELIABLE OPERATION AT FULL RATINGS.

DIRECT INTERELECTRODE CAPACITANCES

WITHOUT SHIELD

GRID 1 TO PLATE	0.8	pf
INPUT	15	pf
OUTPUT	10	pf

HEATER CHARACTERISTICS AND RATINGS

DESIGN MAXIMUM VALUES - SEE EIA STANDARD RS-239

AVERAGE CHARACTERISTICS	6.3	VOLTS	→ 1.6	AMP.

PUSH-PULL AMPLIFIER

VALUES ARE FOR TWO TUBES

DC PLATE VOLTAGE	400	600	400	VOLTS
DC GRID #2 VOLTAGE	275	300	300	VOLTS
DC GRID #1 VOLTAGE	−23	−33	0	VOLTS
CATHODE RESISTOR	---	---	140	OHMS
PEAK AF GRID TO GRID VOLTAGE	46	66	53	VOLTS
ZERO SIGNAL PLATE CURRENT	180	100	166	MA.
ZERO SIGNAL GRID #2 CURRENT	9	3	7.5	MA.
MAXIMUM SIGNAL PLATE CURRENT	270	280	190	MA.
MAXIMUM SIGNAL GRID #2 CURRENT	44	33	39	MA.
LOAD RESISTANCE	3 500	5 000	4 500	OHMS
POWER OUTPUT	55	100	41	WATTS
HARMONIC DISTORTION	3	3.5	4	PERCENT

TUNG-SOL

CONTINUED FROM PRECEDING PAGF

MAXIMUM RATINGS

DESIGN MAXIMUM VALUES - SEE EIA STANDARD RS-239

PLATE VOLTAGE, DC	660	VOLTS
GRID 2 VOLTAGE, DC		
PENTODE CONNECTION	440	VOLTS
TRIODE AND ULTRA-LINEAR CONNECTION	500	VOLTS
GRID 1 VOLTAGE, DC	−300 TO 0	VOLTS
PLATE DISSIPATION	42	WATTS
GRID 2 DISSIPATION		
CONTINUOUS	6.0	WATTS
INTERMITTENT-MUSIC OR SPEECH PEAKS	10.0	WATTS
CATHODE CURRENT, DC	190	MA.
GRID 1 CIRCUIT RESISTANCE		
FIXED BIAS	50	KOHMS
SELF BIAS	250	KOHMS
BULB TEMPERATURE	250	°C

AVERAGE CHARACTERISTICS

PENTODE CONNECTION

PLATE VOLTAGE	250	VOLTS
GRID 2 VOLTAGE	250	VOLTS
GRID 1 VOLTAGE	−14	VOLTS
PLATE CURRENT	140	MA.
GRID 2 CURRENT	12	MA.
TRANSCONDUCTANCE	11,000	μMHOS
PLATE RESISTANCE, APPROX.	15,000	OHMS
TRIODE AMPLIFICATION FACTOR	8	
GRID 1 VOLTAGE FOR 1 MA PLATE CURRENT	−40	VOLTS

TYPICAL OPERATING CONDITIONS

CLASS A1 AUDIO AMPLIFIER - SINGLE TUBE

PLATE VOLTAGE, DC	250	400	VOLTS
GRID 2 VOLTAGE, DC	250	225	VOLTS
GRID 1 VOLTAGE, DC	−14	−16.5	VOLTS
PEAK SIGNAL VOLTAGE	14	16.5	VOLTS
ZERO-SIGNAL PLATE CURRENT, DC	140	87	MA.
MAX. - SIGNAL PLATE CURRENT, DC	150	105	MA.
ZERO-SIGNAL GRID 2 CURRENT, DC	12	4	MA.
MAX. - SIGNAL GRID 2 CURRENT, DC	22	14	MA.
LOAD RESISTANCE	1500	3000	OHMS
TOTAL HARMONIC DISTORTION, APPROX.	7	13.5	PERCENT
MAX. - SIGNAL POWER OUTPUT	12.5	20	WATTS

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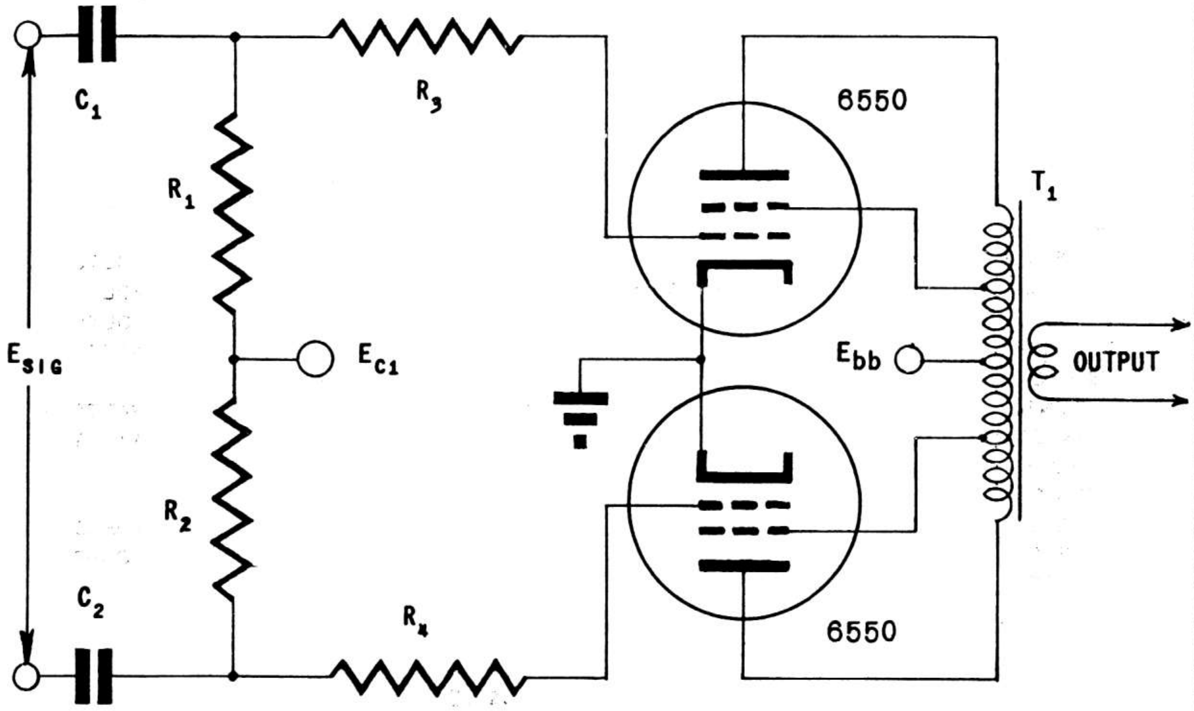
TUNG-SOL

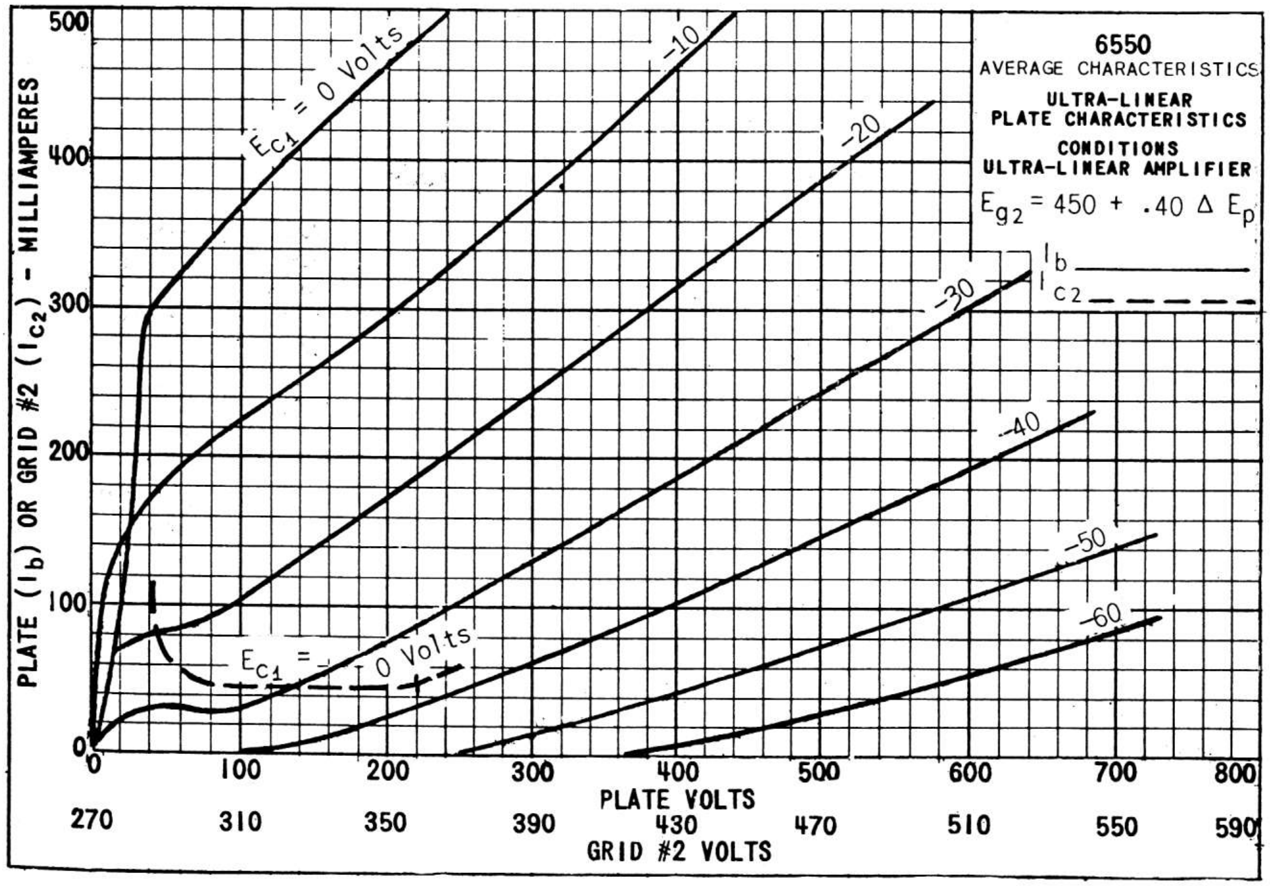
ULTRA-LINEAR OUTPUT STAGE



R_1, R_2 = 50K. 1/2W.	E_{bb} = 450V.	PLATE TO PLATE LOAD = 3.3K.
R_3, R_4 = 1K. 1/2W.	E_{c1} = -48V.	POWER OUTPUT = 70W.
C_1 & C_2 = 0.25µf. 600V.	E_{sig} = 96V. PEAK TO PEAK	TOTAL HARMONIC DISTORTION = 2.5%

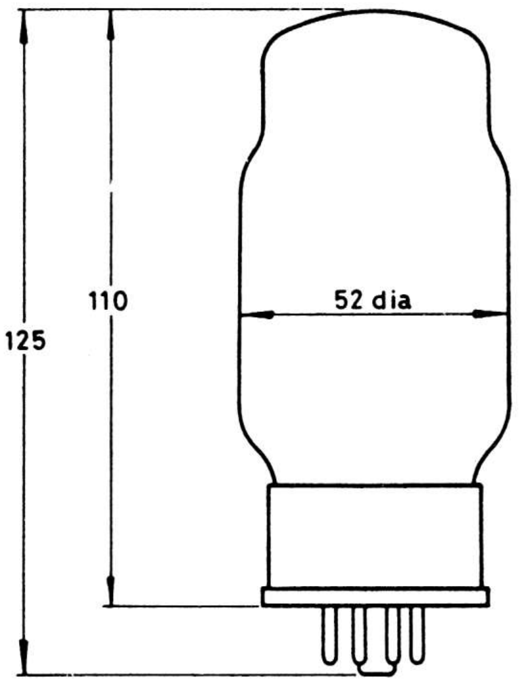
IN THE ULTRA-LINEAR CIRCUIT THE SCREEN VOLTAGES ARE DERIVED FROM TAPS ON THE PLATE WINDING OF THE OUTPUT TRANSFORMER, THE TAPS ARE LOCATED SO AS TO APPLY 40% OF THE PLATE SIGNAL VOLTAGF TO THE SCREEN GRID.

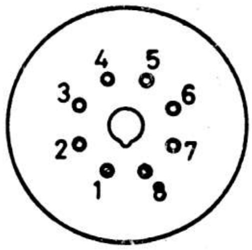
THE PLATE FAMILY FOR THIS CONNECTION IS SHOWN BELOW. THESE CURVES WERE OBTAINED BY STATICALLY VARYING THE PLATE VOLTAGE IN INCREMENTS ABOUT THE QUIESCENT POINT (450 VOLTS PLATE AND SCREEN SUPPLY) AND SIMULTANEOUSLY CHANGING THE SCREEN VOLTAGES BY 40% OF THE INCREMENT. IN THE GRAPH BOTH PLATE AND SCREEN VOLTAGE HAVE BEEN PLOTTED ALONG THE ABSCISSA.



KT88

BEAM TETRODE





1109

Base : Metal shell wafer octal

Pin:

1	base shell	5	g1
2	h	6	NP
3	a	7	h
4	g2	8	k,bp

The KT88 has an absolute maximum anode dissipation rating of 42W and is designed for use in the output stage of an a.f. amplifier. Two valves in Class AB1 give a continuous output of up to 100W. The KT88 is also suitable for use as a series valve in a stabilised power supply.
The KT88 is a commercial version of the CV5220 and is similar to the 6550.

HEATER

V_h	6.3	V
I_h (approx)	1.6	A

MAXIMUM RATINGS

	Absolute	Design Maximum	
V_a	800	800	V
V_{g2}	600	600	V
$V_{a,g2}$	600	600	V
$-V_{g1}$	200	200	V
p_a	42	35	W
p_{g2}	8	6	W
p_{a+g2}	46	40	W
I_k	230	230	mA
$V_{h\text{-}k}$	250	200	V
T_{bulb}	250	250	°C
$R_{g1\text{-}k}$ (cathode bias)			
$p_{a+g2} \leqslant 35W$	470		kΩ
$p_{a+g2} > 35W$	270		kΩ
$R_{g1\text{-}k}$ (fixed bias)			
$p_{a+g2} \leqslant 35W$	220		kΩ
$p_{a+g2} > 35W$	100		kΩ

CAPACITANCES (Measured on a cold unscreened valve)

Triode Connection

$c_{g1\text{-}a,g2}$	7.9	pF
$c_{g1\text{-all less }a,g2}$	9.3	pF
$c_{a,g2\text{-all less }g1}$	17	pF

Tetrode Connection

$c_{g1\text{-}a}$	1.2	pF
$c_{g1\text{-all less }a}$	16	pF
$c_{a\text{-all less }g1}$	12	pF

VTL

Triode Connection. Class AB1. Push-Pull. Cathode Bias.

V_b	270	440	V
$V_{a,g2}$	250	400	V
$-V_{g1}$ (approx)	19	38	V
$V_{in(g1-g1)(pk)}$	38	76	V
*R_k	2 x 345	2 x 615	Ω
$I_{a+g2(o)}$	2 x 55	2 x 62	mA
$P_{a+g2(o)}$	2 x 14	2 x 25	W
$R_{L(a-a)}$	2.5	4.0	kΩ
P_{out}	4.5	14.5	W
D_{tot}	2.0	3.5	%
†IM	3.0	3.0	%
Z_{out}	3.5	3.5	kΩ

*It is essential to use two separate cathode bias resistors.
†Intermodulation distortion : measured using two input signals at 50 and 6000 Hz (ratio of amplitudes 4:1)

Tetrode Connection. Class AB1. Push-Pull. Cathode Bias

$V_{b(a)(o)}$	450	V
$V_{b(a)(max\ sig)}$	425	V
$V_{a(o)}$	415	V
$V_{a(max\ sig)}$	390	V
$V_{g2(o)}$	300	V
$V_{g2(max\ sig)}$	275	V
$-V_{g1}$ (approx)	27	V
$I_{a(o)}$	2 x 52	mA
$I_{a(max\ sig)}$	2 x 62	mA
$I_{g2(o)}$	2 x 2.5	mA
$I_{g2(max\ sig)}$	2 x 9	mA
$P_{a(o)}$	2 x 21	W
$P_{a(max\ sig)}$	2 x 9	W
$P_{g2(o)}$	2 x 0.75	W
$P_{g2(max\ sig)}$	2 x 2.5	W
*R_k	2 x 500	Ω
$R_{L(a-a)}$	8	kΩ
$V_{in(g1-g1)(pk)}$	70	V
P_{out}	30	W
D_{tot}	6	%

*It is essential to use two separate cathode bias resistors.

Ultra-linear Connection. Push-Pull. 40% Taps. Class AB1. Cathode Bias.

V_b	450	V
$V_{a,g2(o)}$	425	V
$V_{a,g2(max\ sig)}$	400	V
$I_{a+g2(o)}$	2 x 62.5	mA
$I_{a+g2(max\ sig)}$	2 x 72.5	mA
$P_{a+g2(o)}$	2 x 26.5	W
$P_{a+g2(max\ sig)}$	2 x 13	W
*R_k	2 x 560	Ω
$-V_{g1}$ (approx)	35	V
P_{out}	32	W
$R_{L(a-a)}$	7	kΩ
Z_{out}	9	kΩ
D_{tot}	2	%
†IM	4	%

*It is essential to use two separate cathode bias resistors.
†Intermodulation distortion : measured using two input signals at 50 and 6000 Hz (ratio of amplitudes 4:1).

Ultra-linear Connection. Class AB1. Push-Pull. 40% Taps. Fixed Bias.

$V_{a,g2(o)}$	525	V
$V_{a,g2(max\ sig)}$	500	V
$I_{a+g2(o)}$	2 x 35	mA
$I_{a+g2(max\ sig)}$	2 x 80	mA
$p_{a+g2(o)}$	2 x 18	W
$p_{a+g2(max\ sig)}$	2 x 15	W
* $-V_{g1}$ (approx)	67	V
$R_{L(a-a)}$	8	kΩ
$V_{in(g1-g1)(pk)}$	127	V
P_{out}	50	W
D_{tot}	3	%
†IM	15	%
Z_{out}	10	kΩ

*A negative bias range of ±25% of this value should be available for each valve.

†Intermodulation distortion : measured using two input signals at 50 and 6000 Hz (ratio of amplitudes 4:1)

LIFE PERFORMANCE

The average life expectancy of the KT66 when operated at absolute maximum ratings (see page 1) is at least 8000 hours. At a reduced rating of p_{a+g2} = 21 W a life of at least 10,000 hours should be obtained. The environment must be a static one and the valve should be switched not more than 12 times in each 24 hours.

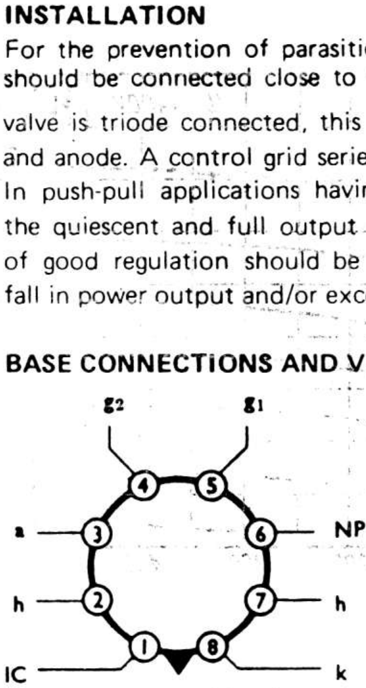
A valve is considered to have reached the end of life when it is either inoperative or one or more of its characteristics have reached the following values:

P_{out}	50% of initial value	
* g_m	<5.5	mA/V
*Measured at:		
V_a	250	V
V_{g2}	250	V
I_a	85	mA

INSTALLATION

For the prevention of parasitic oscillation, a series resistor of 100–300 Ω should be connected close to the screen tag of the valve socket. When the valve is triode connected, this resistor should be connected between screen and anode. A control grid series resistor of 10–50 kΩ is also recommended. In push-pull applications having a large change in anode current between the quiescent and full output conditions, an inductance input filter circuit of good regulation should be used. A badly regulated supply will cause a fall in power output and/or excessive quiescent anode dissipation.

BASE CONNECTIONS AND VALVE DIMENSIONS



View from underside of base.

Base :	International Octal (B8–0)
Bulb :	Dome top tubular
Max. overall length :	135 mm
Max. seated length :	121 mm
Max. diameter :	53 mm

The tube may be mounted either vertically or horizontally.

When tubes are mounted vertically it is recommended that the centres of the tube sockets are not less than 4in. apart and that pins 4 and 8 of each tube are in line.

When tubes are mounted horizontally it is recommended that the centres of the tube sockets are not less than 4in. apart and that pins 4 and 8 of each tube are in the same vertical line. One tube should not be mounted directly above another.

Free air circulation around the tube is desirable.

CHARACTERISTICS

Tetrode Connected

V_a	250	V
V_{g2}	250	V
I_a	140	mA
I_{g2} (approx)	3	mA
$-V_{g1}$ (approx)	15	V
g_m	11.5	mA/V
r_a	12	kΩ
$\mu_{g1\text{-}g2}$	8	

Triode Connected

$V_{a,g2}$	250	V
I_{a+g2}	143	mA
$-V_{g1}$ (approx)	15	V
g_m	12	mA/V
r_a	670	Ω
μ	8	

TYPICAL OPERATION

Push-Pull. Class AB1. Cathode Bias. Tetrode Connection

$V_{a(b)}$	560	V
$V_{a(o)}$	521	V
V_{g2}	300	V
$I_{a(o)}$	2 x 64	mA
$I_{a\,(max\,sig)}$	2 x 73	mA
$I_{g2(o)}$	2 x 1.7	mA
$I_{g2\,(max\,sig)}$	2 x 9	mA
$R_{L(a\text{-}a)}$	9	kΩ
*R_k	2 x 460	Ω
$-V_{g1}$ (approx)	30	V
P_{out}	50	W
D_{tot}	3	%
‡I.M.	11	%
$p_{a(o)}$	2 x 33	W
$p_{a(max\,sig)}$	2 x 12	W
$p_{g2(o)}$	2 x 0.5	W
$p_{g2\,(max\,sig)}$	2 x 2.7	W
$V_{(g1\text{-}g1)(ac)}$ crest	60	V

*It is essential to use two separate cathode bias resistors.

‡Intermodulation distortion; measured using two input signals at 50 and 6000Hz (ratio of amplitudes 4:1).

PPPP

VTL

KT 88

Push-Pull. Class AB1. Fixed Bias. Tetrode Connection

$V_{a(b)}$	560	V
$V_{a(o)}$	552	V
V_{g2}	300	V
$I_{a(o)}$	2 x 60	mA
$I_{a\ (max\ sig)}$	2 x 145	mA
$I_{g2(o)}$	2 x 1.7	mA
$I_{g2\ (max\ sig)}$	2 x 15	mA
$R_{L(a\text{-}a)}$	4.5	kΩ
*$-V_{g1}$ (approx)	34	V
P_{out}	100	W
D_{tot}	2.5	%
ǂI.M.	10	%
$p_{a(o)}$	2 x 33	W
$p_{a\ (max\ sig)}$	2 x 28	W
$p_{g2(o)}$	2 x 0.5	W
$p_{g2\ (max\ sig)}$	2 x 4.5	W
$V_{(g1\text{-}g1)(ac)}$ crest	67	V

*It is essential to provide two separately adjustable bias voltage sources, having a voltage adjustment range of ±25%.

ǂIntermodulation distortion; measured using two input signals at 50 and 6000Hz (ratio of amplitudes 4:1).

Push-Pull. Class AB1. Fixed Bias. Ultra-Linear Connection. (40% Tapping Points)

$V_{a,g2(b)}$	560	460	V
$V_{a,g2(o)}$	553	453	V
$I_{a+g2(o)}$	2 x 50	2 x 50	mA
$I_{a+g2\ (max\ sig)}$	2 x 157	2 x 140	mA
$R_{L(a\text{-}a)}$	4.5	4	kΩ
*$-V_{g1}$ (approx)	75	59	V
P_{out}	100	70	W
D_{tot}	2	2	%
ǂI.M.	11	10	%
$p_{a+g2(o)}$	2 x 27.5	2 x 22.5	W
$p_{a+g2\ (max\ sig)}$	2 x 33	2 x 27	W
$V_{(g1\text{-}g1)(ac)}$ crest	140	114	V
Z_{out}	7	6.5	kΩ

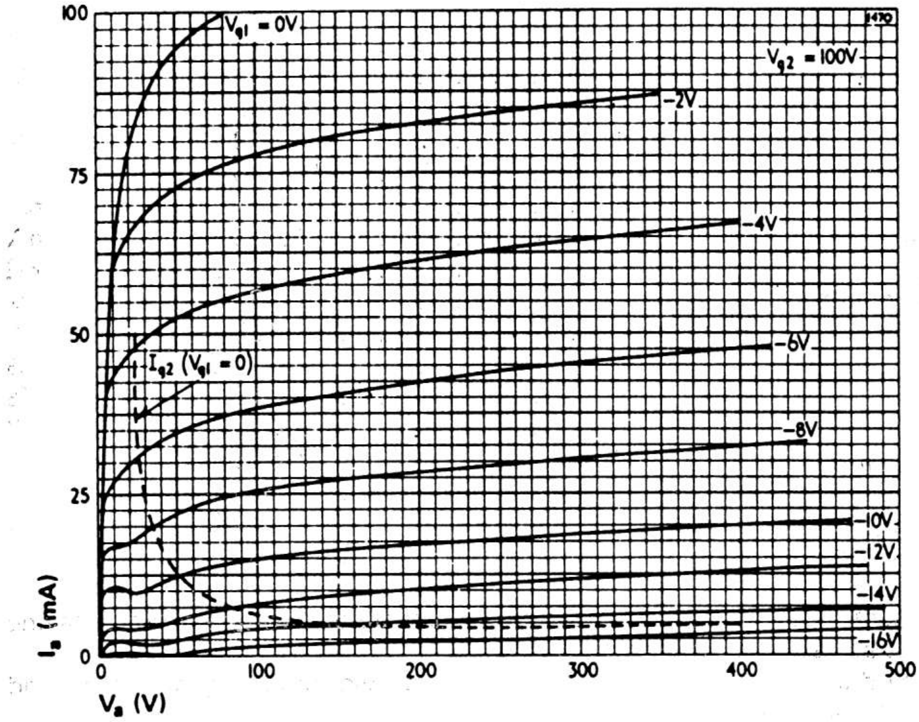
*It is essential to provide two separately adjustable bias voltage sources, having a voltage adjustment range of ±25%.

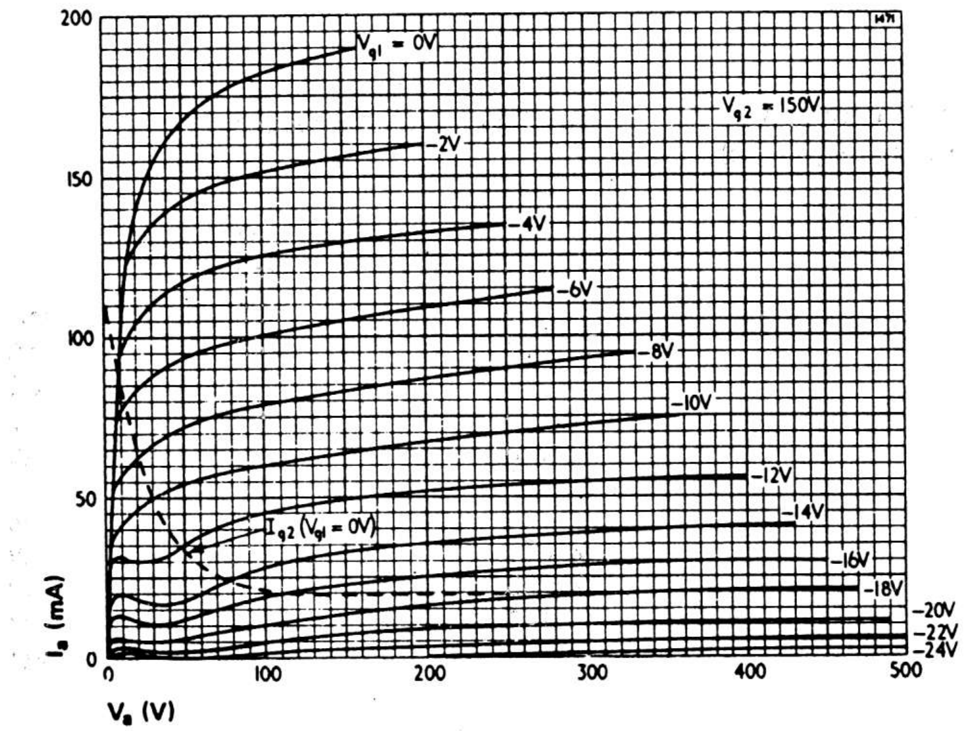
ǂIntermodulation distortion; measured using two input signals at 50 and 6000Hz (ratio of amplitudes 4:1).

PPPPP

VTL

KT88





VTL

GEC

KT66

BEAM TETRODE

BRIEF DATA

A beam tetrode with an absolute maximum anode dissipation rating of 30 W. It is designed for use in the output stage of an a.f. amplifier, or as a series valve in a stabilized power supply.
The KT66 is a commercial version of the CV1075.

HEATER

Heater voltage	6.3	V
Heater current (approx)	1.3	A

MAXIMUM RATINGS

	Design Max	Absolute Max	
DC anode voltage	500	550	V
DC screen voltage	500	550	V
Negative dc grid voltage	200	200	V
DC cathode current	200	200	mA
Anode dissipation	25	30	W
Screen dissipation	3.5	4.5	W
*Anode and screen dissipation	27	32	W
Heater-cathode voltage	150	150	V
Bulb temperature	250	250	°C
External grid-cathode resistor (cathode bias):			
$p_{a+g2} \leq 27$ W	1.0		MΩ
$p_{a+g2} > 27$ W	500		kΩ
External grid-cathode resistor (fixed bias):			
$p_{a+g2} \leq 27$ W	250		kΩ
$p_{a+g2} > 27$ W	100		kΩ

*Triode or ultra linear operation.

CAPACITANCES (Measured on a cold unscreened valve)

Grid to all less anode	14.5	pF
Anode to all less grid	10.0	pF
Anode to grid	1.1	pF

CHARACTERISTICS

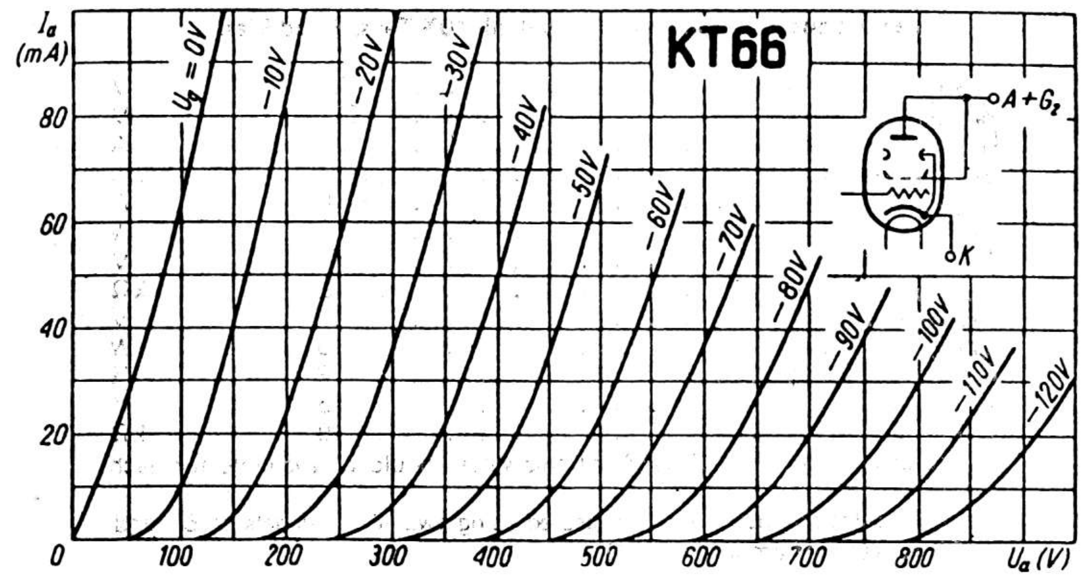
Tetrode Connection

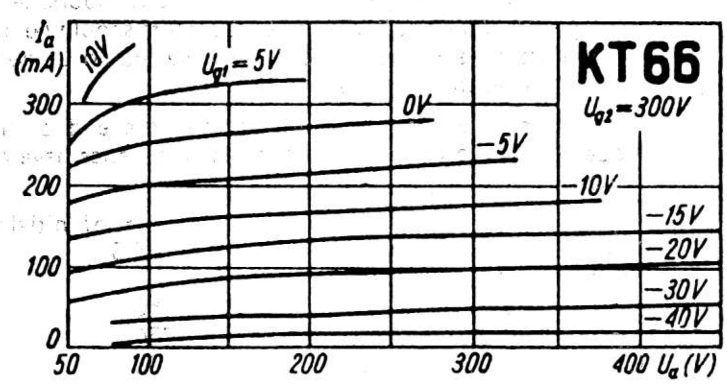
DC anode voltage	250	V
DC screen voltage	250	V
Negative dc grid voltage	15	V
Mutual conductance	7	mA/V
Internal anode resistance	22.5	kΩ

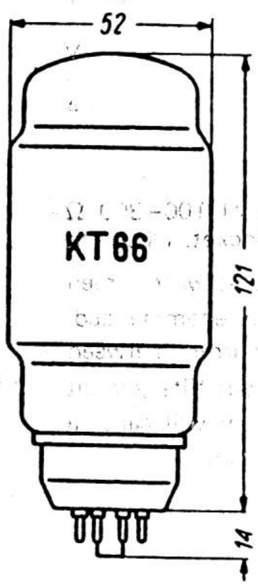
Triode Connection

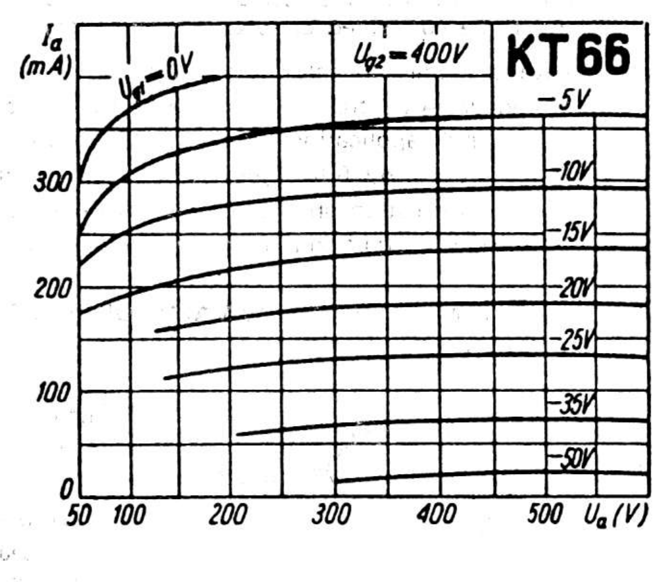
DC anode voltage	250	V
Negative dc grid voltage	15	V
Mutual conductance	7.3	mA/V
Internal anode resistance	1.3	kΩ

VTL

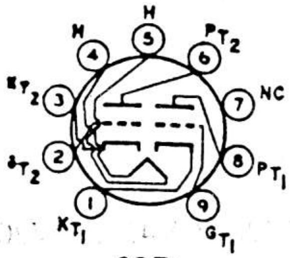

KT66
I_a (mA)
80
60
40
20
0
100
200
300
400
500
600
700
800
U_a (V)
U_g = 0V
−10V
−20V
−30V
−40V
−50V
−60V
−70V
−80V
−90V
−100V
−110V
−120V
A + G_2
K


KT66
U_{g2} = 300V
I_a (mA)
300
200
100
0
50
100
200
300
400
U_a (V)
10V
U_{g1} = 5V
0V
−5V
−10V
−15V
−20V
−30V
−40V


52
KT66
121
14


KT66
U_{g2} = 400V
I_a (mA)
300
200
100
0
50
100
200
300
400
500
U_a (V)
U_{g1} = 0V
−5V
−10V
−15V
−20V
−25V
−35V
−50V

VTL



9QD

DUAL TRIODE

6GF7A

10GF7A, 13GF7A

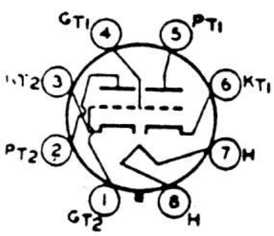
Novar types used as combined vertical-deflection oscillator and vertical-deflection amplifiers in color and black-and-white television receivers. Outlines section, 30A; requires novar 9-contact socket. For curves of average plate characteristics for Unit No.1 and Unit No.2, refer to types 6DR7 (Unit No.1) and 6EM7, respectively. Types 10GF7A and 13GF7A are identical with type 6GF7A except for heater ratings.

	6GF7A	10GF7A	13GF7A	
Heater Voltage (ac/dc)	6.3	9.7	13	volts
Heater Current	0.985	0.6	0.45	ampere
Heater Warm-up Time (Average)	—	11	11	seconds
Heater-Cathode Voltage:				
Peak value	±200 max	±200 max	±200 max	volts
Average value	100 max	100 max	100 max	volts

Direct Interelectrode Capacitances (Approx.):	Unit No.1	Unit No.2	
Grid to Plate	4.6	9	pF
Grid to Cathode and Heater	2.4	6.5	pF
Plate to Cathode and Heater	0.26	1.4	pF

Class A_1 Amplifier

CHARACTERISTICS	Unit No.1	Unit No.2	
Plate Voltage	250	150	volts
Grid Voltage	—3	—20	volts
Amplification Factor	64	5.4	
Plate Resistance (Approx.)	40000	750	ohms
Transconductance	1600	7200	µmhos
Grid Voltage (Approx.):			
For plate current of 10 µA	—5.5	—	volts
For plate current of 100 µA	—	—45	volts
Plate Current	1.4	50	mA
For plate voltage of 60 volts and zero grid voltage	—	95	mA
For grid voltage of —28 volts	—	10	mA



8BD

6EM7/6EA7

DUAL TRIODE

10EM7, 13EM7/15EA7

	6EM7/6EA7	10EM7	13EM7/15EA7	
Heater Voltage (ac/dc)	6.3	9.7	13	volts
Heater Current	0.925	0.6	0.45	ampere
Heater Warm-up Time (Average)	—	11	11	seconds
Heater-Cathode Voltage:				
Peak value	±200 max	±200 max	±200 max	volts
Average value	100 max	100 max	100 max	volts

Direct Interelectrode Capacitances (Approx.):	Unit No.1	Unit No.2	
Grid to Plate	4.8	10	pF
Grid to Cathode and Heater	2.2	7	pF
Plate to Cathode and Heater	0.6	1.8	pF

Class A_1 Amplifier

CHARACTERISTICS	Unit No.1	Unit No.2	
Plate Voltage	250	150	volts
Grid Voltage	—3	—20	volts
Amplification Factor	64	5.4	
Plate Resistance (Approx.)	40000	750	ohms
Transconductance	1600	7200	µmhos
Plate Current	1.4	50	mA
Plate Current, for plate voltage of 60 volts and zero grid voltage	—	95	mA
Plate Current, for grid voltage of —28 volts	—	10	mA
Grid Voltage (Approx.):			
For plate current of 10 µA	—5.5	—	volts
For plate current of 100 µA	—	—45	volts

TUBE SUBSTITUTION LIST

12AT7: ECC81, 6201, E81CC, ECC801, B309, 6060, 6679, 7728, CV455, CV2016, CV8154.

12AU7: ECC82, E82CC, 6067, B339, 5814, 6189, 6680, 7730, CV491, CV8155.

12AV7: 5965.

12AX7: ECC83, E83CC, ECC803, 7025, 5751, 7058, 7729, 6681, CV492, CV8156.

6BQ5: EL84, N709, 7189, 7320.

6DJ8: ECC88, E88CC, 6922.

EF86: 6BK8, Z729, 6CF8, 6267.

ECC807 — no equivalent.

KT88 — no equivalent.

6550 — no equivalent.

7027A — no equivalent.

7868 — no equivalent.

8417 — no equivalent.

300B – no equivalent.

6CA7/EL34.

6L6: 6L6G, 6L6GC, 5881 (20% up-rated) 6BG6 (30% up-rated).

807: CV124, KT66 (very close; different base) ATS25, ARS25, CV1060, CV1364, CV1572, HY61, P17A, QV05/25, RK39, UY807.