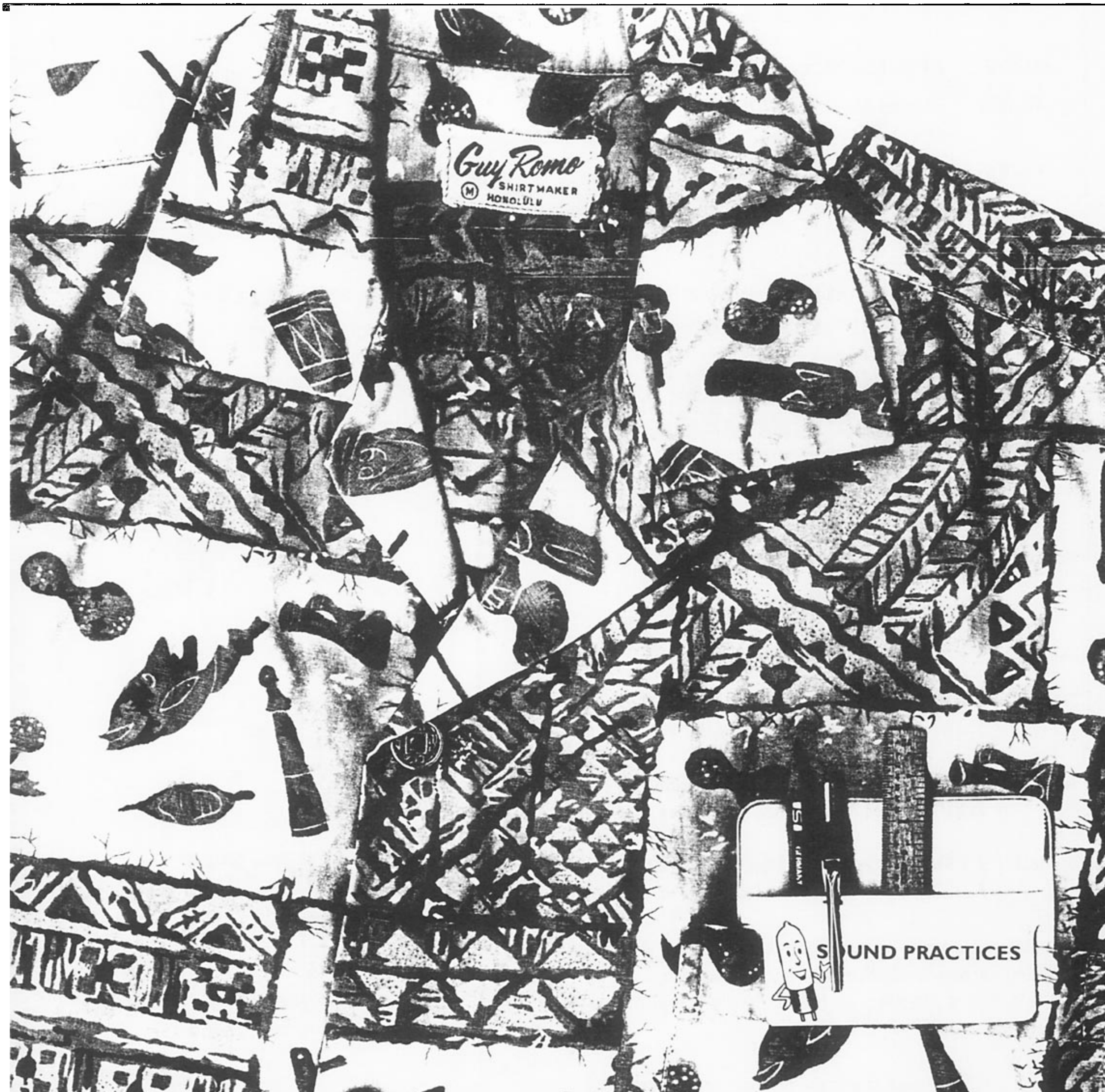
SOUND PRACTICES

A JOURNAL OF AUDIO TECHNOLOGY FALL 1992 FIVE DOLLARS



New Sonic Fashions Issue

Vol 1: #2

Sound Practices

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Sound Practices actively solicits contributions of written material of interest to our readership. Please contact us to discuss your ideas. We are open to articles on all sound practices.

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Fall 1992 Contents

A matter of CHOICE

The vast range of audio technology developed over the past 80 years is one of our century's gifts to humanity. And it's the best kind of gift there is: the kind you are free to accept or decline according to your own lights. However, REAL free choice requires looking at *all* of the alternatives - past, present, and possible. There is a tremendous array of options in audio, especially if you don't limit yourself to the products advertised in last month's *High End Rag.* I am sure many people took one look at *Sound Practices* #1 and concluded that it wasn't for them. True, *Sound Practices* is surely not for everyone. *Sound Practices* is about expanding the boundaries of the discourse. Some seem to like things alright just as they are.

In this age of technical passivity, the appearance of schematics and (*heaven forbid!*) equations will scare off many casual readers. Hope you at least think it over before you retreat. Aside from undergoing an interesting learning experience for its own sake, you can radically expand your *practical* options as you acquire enough technical know how to build your own equipment, modify units to your preferences, and maintain "obsolescent" gear. In an age when most are content to choose from a fancy display of hermetically sealed appliances, your soldering iron and your library are powerful weapons of free choice. With a bit of knowledge and brainpower you can do some serious damage to the "appliance consumer" mentality.

Unbelievable that "back in the day", you could actually learn practical audio electronics by reading the newsstand Hi-Fi magazines. *AUDIO* in 1992 won't get you there the way *AUDIO* did in 1955 or the way *RADIO NEWS* did in 1945. The strict division between producers and consumers inherent in today's marketplace is reflected in the typology of contemporary audio magazines: in general, either you get a glossy "Buyer's Guide" or you get a dense journal you have to be a rocket scientist to hack through. The middle ground is the most valuable territory for many of us and that's where *Sound Practices* will set up camp.

You will probably find a few statements which will alienate some hyper-fi types. Sorry, Audio as practiced by devotees of the Cult of the High End is NOT the only legitimate form of *serious* audio experimentation. Many of the most perceptive audiophiles I know don't read *any* of the High End mags. Of course, you don't hear much about these people because they haven't had a magazine to champion their causes. Not much commercial potential in folks happy with "old" gear and DIY stuff. They are "invisible audiophiles" but some of them are at the leading edge of audio experimentation. A few are even dangling *over* the edge!

High End Audio as propounded by the Gurus is a strict and dogmatic discipline. Although the tendency is not to see it that way, a very narrow aesthetic guides the subjective review process. Words like "neutral", "accurate", "detail" are loaded terms which carry a lot of ideological baggage. Whaaat? How can you be a *serious* listener and not want *more* detail? Or more of that dry, analytical NEUTRAL presentation? Or a more UN-COLORED sound? Some gear is even so uncolored it offers far less color than music itself. If you're a detail freak there are a few products out there that will give you a sense of more detail than ever graced the stage. The point I'm trying to make is don't buy it just because THEY say it's good, decide for yourself. A lot of the high end stuff images great but you can forget much of it if you wanna boogie down or bop out.

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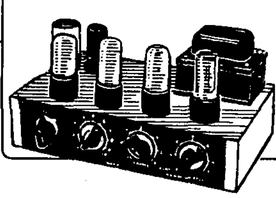

NEW PRODUCTS

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The Impulse loudspeakers, horn loaded designs greatly favored by certain members of the audiophile press in the UK, are represented in the US market by importer Renaissance Sound. There are three models available - retail prices start at $1995. Dealer and end-user inquiries invited.

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THE BOOK ON WESTERN ELECTRIC TUBES

Antique Electronic Supply has just released ***75 Years of Western Electric Tube Manufacturing***, a 140 page book which describes and pictures over 750 WE tubes in a handy numerically organized format. The author, Bernard Magers, was a Senior Engineer at WECO involved with tube production at the Kansas City Works, final home of the 300B. A brief historical overview of manufacturing at WECO, a summary of tube manufacturing notes, and a useful bibliography are provided. Magnetrons get more coverage than audio tubes but the serious student of vacuum tube technology will find this $16.95 volume to be a worthwhile investment and a valuable addition to the literature on the subject.

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ETE provides photofacts and schematics of many popular classic audio products at $2.50 each. Their free tube catalog lists 3000 types including many popular audio tubes.

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CHOICE (continued from page 1)

The preferences legislated by the High End Gurus are adopted by many, sometimes consciously and with intelligence but often without perspective or prior reflection. We all know hard-core audiophiles who listen ONLY to Reiners and Mercury Living Presences on Editor's Choice gear. Sure, I'm glad I heard *Casino Royale* on Jeff Rowland electronics and Infinity Betas, but I must say I had a mo' better time listening to Hank Williams 78s on Western Electric speakers and some very scary looking homebrew electronics. Never was a big Herb Alpert fan. Joining in the grail quest of audio writers best known by their initials is engaging I suppose but it's no cause for snobbery and exclusionism. And it's definitely not the last word. There is no last word in this game. Audio is about *your* preferences and *your* tastes, or at least it should be.

The aesthetic foregrounded by High End pundits becomes an important element in the design equation since manufacturers have to impress this group to survive. The High End reproduces itself in this manner. What we got here folks is *sonic fashion*. Parts, circuit topologies, and more fundamental factors like the choice of media or encoding systems all help define the "in thing" in sound. You can step out of the parade anytime you want - no need to wait for the Recommended Components List to lead the way.

There is an internal contradiction in the High End dogma that reproduction must be scrupulously evaluated in comparison with a utopian ideal of "live unamplified acoustic music." Focus on such an impossible goal encourages preoccupation with what is wrong with the system. Why not turn it around and look at what a system does well? How can you listen for failings and enjoy whatever you're hearing? No wonder so many enthusiasts burn out on *audio* and retreat to the happy pastures of music listening. Attitude is more instrumental than hardware in the pursuit of musical enjoyment.

Even at its best, reproduction is illusion, in short, a LIE. Should audio be reduced to a quest for the best liar? Maybe. Why not pick a fibster with a style you find personally convincing. Learn to appreciate the particular style of deception the masterful con artist brings to his craft. Suspend disbelief and journey ahead. Accept that you'll never get the absolute musical truth out of a pile of parts and wire. Let the Audio Priests pursue the impossible goals. Let the rest of us make our own choices.

As I see it, the major challenge faced by *Sound Practices* is to promote alternatives without falling into its own predicable routine. Sure, there is a dire need for discussion about single ended and triode amps - if only to fill in the gaping void in the English language literature. But I recognize that not everyone shares my undying passion for 10 pound per watt amps. This stuff can get as boring as Dynaco mods with prolonged exposure. (Well, almost).

Come on, even the most dedicated tube freak must admit that transistor amps have come a long, long way and can equal tube gear in overall quality, even if our subjective preferences lie with our trusty "hollow state" gear. So let's keep the discourse wide open. If you've had it with WWII-era triodes or whatever, let me know. Better yet, consider sharing *your* hard earned insights and sonic achievements with your fellow readers. *Sound Practices* - like everything else in your audio life - will be exactly what you make it.

Art at the Edge of Science

The sonic explorations of Kondo-san

by Joe Roberts

Audio experimenters have uncovered many gaps in the models textbook science brings to bear on electro-acoustical phenomena. This can be a source of bafflement and embarrassment to authorities in the field, but our ears have proven their value as a most subtle evaluation device - one which hears things that *can't* be there. Many scientists take the comfortable and logical way out and deny the possibility of unmeasurable "new" audio phenomena.

For example, in the Spring 1991 issue of *The Skeptical Inquirer*, Fred E. Davis gave us "Hi-Fi Audio Pseudoscience," an article committing cables, AC cords and conditioners, CD treatments, and novel uses for digital clocks to the shady realms of mysticism and the powers of suggestion. He doesn't claim to have done much listening. Surely not worth the trouble based on mathematical models. Yet most of this study was based on "skimming through three or four audio magazines." Very rigorous method indeed!

As audio experimenters realize, there are other ways we can "know" aside from formal scientific research. There is a distinction between *"knowing how"* and *"knowing that."* Both ways of knowing are achieved through an empirically based trial and error process. The difference is that *knowing that* doesn't have the same dependence on an explanatory model. We can recognize what happens and even learn to predict what is going to happen without understanding the "mechanics" of the process. "Discoveries" can often be put to good use without understanding *how* they work.

Before science was appropriated by large institutions like universities, government research facilities, and industry "think tanks", the independent inventor was the main agent of scientific discovery, often relying on inspiration and trial rather than theory to guide their experiments. Much of the interesting work in audio is still done this way.

Informal exploration in audio is not governed by the strict etiquette of white lab coat science. Nowadays there's no grant money available to research exotic claims in high end audio so don't expect much attention from BIG science. Progress in audio is a challenge for underfunded, imaginative, and independent experimenters to address on their own terms, often in their own basement or listening rooms.

The range of experimental strategies that have been applied in high end audio defies summation. Investigators span the range from "new physicists" like Peter Belt and George Tice to material hackers who spend weeks listening to interconnects made from different kinds of solder. Iron bricks, demagnetizers, tuning dots, lead bars, wires, air bearings, precious metals, contact enhancers, spikes, green pens, carbon fibers: the conceptual variety of tweak experimentation is staggering. You really have to stop and wonder where the inspiration for some of these experiments arose.

All hype, politics, and mysticism aside, if you've been experimenting you know that some very "unlikely" treatments can change the sound you hear. Usually you get *different* rather than *distinctly better*. But there is often a real effect, sometimes subtle and sometimes profound. In time, products we all laughed about at first, like "special wire," show up on the shelves at Radio Shack.

All over the world, the appreciation of classic audio gear for its historical, sonic, and fetish value is growing. At the same time, designers are reevaluating long abandoned technologies like triode output stages, single ended amplifiers, and horn loaded speakers with well trained modern ears. Even though it has been done before, new realizations are emerging this time around. Turns out that some things we all thought was junk can sound great and vice versa. Concepts of progress are being reevaluated and textbooks haven't caught up yet.

As long as theory lags behind practice, audio artists will constitute the leading edge. Some of the best students *are* trained scientists and real engineers. But the most vital arena of investigation lies a bit beyond the edges of science.

THE QUESTION OF STYLE

Audio Note's Hiroyasu Kondo, like other great audio artists, gives us a family of designs with distinctive vision and *style*. Kondo's peer group is the Japanese Ultra-Fi audio culture. A product like a single ended 211 or 300B amp is fairly typical in Japan, where appreciation of classic audio technology is highly developed. In the States, such products are still so far out they elicit blank stares from most audiophiles. Viewed in its native context, the work of Kondo-san reflects a conventional style but it incorporates a powerful personal statement on the art and science of audio worldwide.

The extensive use of silver is one hallmark of an Audio Note creation but there are other stylistic features which point back to the hand of Kondo. For example, he uses certain tube types across the entire line and they reappear like signature riffs in a blues tune. The 6072A is usually the low level tube, the driver is typically a 5687. Output tubes are drawn from the directly heated triode family - 211, 2A3, and 300B. Most of the tubes Kondo employs are audio classics or highly specified military/industrial bottles well qualified for the task. The 6072A, for example, is listed in the RCA manual under "Premium Tubes - designed to meet military specifications and critical industrial applications." What more critical application exists than a $60,000 amplifier? Kondo's preferred tube lineup appears not only in the Audio Note amplifiers. The M7 tube preamplifier also relies on, you guessed it, 6072A s and 5687s throughout.

Kondo uses different tubes in each stage in different configurations to avoid additive distortion and to cancel the kinds of distortion each stage introduces. This is said to be a Japanese high end group style technique. Kondo-san's personal style seems to be an SRPP (series regulated push pull) 6072A input stage direct coupled to a 5687 voltage amp, then cap coupled to a 5687 cathode follower driver for directly heated triodes.

Every component of Kondo's products gets special consideration. He hand rolls silver foil oil caps and prefers custom tantalum film resistors - said to offer a degree of grainlessness that no other resistor can match. Audio Note specifies special order units with silver leads and end caps! His circuits are built around luxurious silver wound output transformers and solid copper chassis. Kondo-san's sonic artistry is in realization as much as design.

SILVER

In the USA, the audiophile community is strongly divided on the issue of silver wire. Some love it and others hate it. The usual lack of solid theoretical grounding applies here. True, silver is a slightly better conductor than copper but not by enough to really matter in terms of resistance. The question of the sound of materials is a cloudy area conceptually but one which has proven to be very important in practice.

The best answer I got on why silver might sound so good came from Randy Bradley at Bear Labs, a maker of well-regarded silver cables, who offered "Nobody knows *why*, but *when properly applied*, it does." Kondo is said to be carrying out experiments in hopes of determining why silver sounds the way it does. In a way, this study is purely academic. Whether he finds out or not, the cables will still sound the way they do. The sound is what matters.

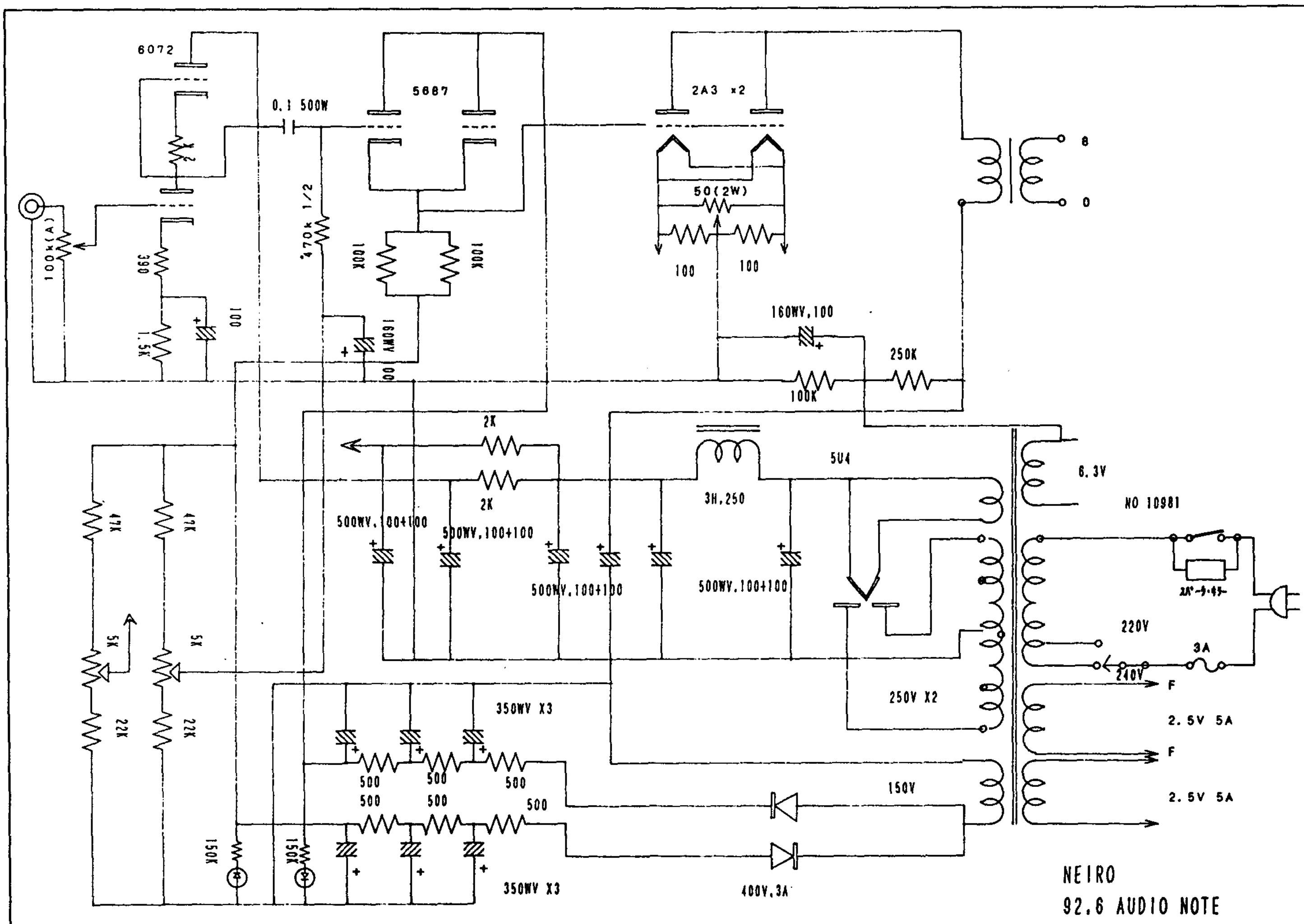
As with all wire, success with silver has to do with cable topology and system matching. It's not something to be used randomly. Audio Note promotes a well reasoned systems approach to the use of silver: the best thing to do is to use silver everywhere. Disjunctions between metals should be minimized for best sonic results. If only partially cabling up with silver, it is best used up front, they argue, since 'copper distortions' will be rendered more obvious by silver downstream. Systems with problems like poor contacts and inferior wire elsewhere, should avoid AN silver since it will disclose any prevailing weakness in the system.

Audio Note claims that some combinations of copper wire with AN silver can result in a substantial increase in high frequency response and occasionally loss of lows, causing the system to sound too bright. This is the classic critique of silver wire. Maybe the sin of silver is *disclosure* not *commission.*

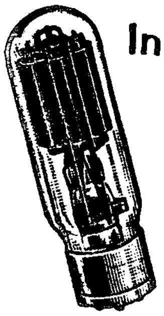
All silver is not equal, most audio silversmiths would claim. Audio Note silver is not your usual off the shelf silver. It is high purity (99.99%) although other silver cables are more pure (e.g. Kimber @ .99999). AN silver is imported from Italy and specially processed from ingots at the Tokyo plant. It is cold drawn through a diamond die and immediately coated with several layers of polyurethane to forestall oxidation and mechanically dampen the surface of the wire to prevent "wire crying". Audio note argues that even tiny amounts of surface oxidation cause sonically detrimental rectifying effects which negate the advantages of AN silver.

In the Audio Note UK literature, AN silver cables are claimed to be their most "important product." In Kondo's article which follows, he seems very impressed with the aural qualities of silver wire and enchanted with the sound of his hand rolled silver foil oil caps and his custom silver wound output transformers. Silver is the heart of Audio Note. Unfortunately, as Peter Qvortrup of Audio Note UK observes, "Using the purest available silver as a conductor, naturally has the same effect on price as it has on sound quality: it is automatically high."

TO BE CONTINUED NEXT ISSUE



The Audio Note *Neiro 7.5W* parallel single-ended 2A3 amplifier. Note stylistic similarity with *Ongaku* circuit (overleaf).



In this way, I made up the 211S amplifier and named this amplifier "ONGAKU"...

Hiroyasu Kondo, Audio Note, Inc.

I LOVE THE 211

The 211 creates a formidable impression because of its shape. But the 211 may appear old-fashioned and unsophisticated to high-brow maniacs for audio equipment. Perhaps this is the reason why there are only a few amplifiers that employ the 211 tube today.

This type of amplifier is a challenge from the viewpoint of the manufacturer. The power supply circuit cannot be normally designed, since the supply voltage required for the 211 tube must be approximately 1000V. In manufacturing the amplifier, we must pay utmost attention to moisture-proofing the chassis and proper insulation of the wiring so as to prevent hands from getting electric shock if one reaches into the amplifier.

However, it is only large triodes like the 211 that provide the best performance that vacuum tubes can offer. The Eg-Ip characteristic of the 211 and its brothers is more linear than most other power tubes. Larger diameter wire is used for the heater, the grid to heater spacing is considerable, and coarse "pitch" is used for the grid winding geometry. This type of vacuum tube is very sturdy and promises a high vacuum integrity, since it was originally intended for demanding commercial and military applications.

When high plate voltage is employed and the pitch of the grid is made more coarse, the amount of "stray electrons" around the heater is greatly decreased, thereby allowing the vacuum tube to work in a more closely ideal manner. In particular, the large triode vacuum tube functions more perfectly when dealing with low level signals, allowing the tone quality to be clear and distinct. If the design of the driver stage is satisfactory, the single triode power amplifier possesses an unbelievably low distortion characteristic, even in the absence of negative feedback. This fact demonstrates the excellent performance of this family of vacuum tubes.

SIMPLE IS THE BEST

What does "good sound" mean? There may be a variety of interpretations. However, a good sound must mean a "natural sound". The meaning of "natural sound" depends on the interpretation of the word. There may be differing opinions -such as "natural" means a sound "without mechanical sound" or that it means a sound "alike to live sound". All listeners would agree that natural sound must not include mechanical sound. A mechanical sound will paralyze the listener's senses when listening to the music for an extended period of time. There are many factors which can produce mechanical sound.

It is an interesting discovery that when mechanical sounds are thoroughly eliminated, we *can* reproduce live sound. What must we do to eliminate mechanical sound? First, we must simplify the audio circuitry. Next, we must carefully select the components which are used in the equipment.

At the closing stage of the vacuum tube amplifier age, tube circuit technology was in a highly advanced state. It was like the advanced evolution of dinosaurs at the close of the dinosaurian age. When I was only 20 years old, I concentrated my energies on the study of "negative feedback theory". At such an inexperienced age, one tends to concentrate on a meeting point, where theory seems to meet reality, instead of focusing on the sound itself. I still remember that I was trying to make up an ideal circuit so as to produce a good sound and my soldering iron was always in its heated state. In spite of my efforts, I could not go beyond the wall of "good" sounds. I finally arrived at the conclusion, after considerable trial and error, that the most important thing is to "make up an amplifier without depending on negative feedback." In fact, I found that I had to strive to simplify the circuitry even without negative feedback and also to develop my understanding of the characteristics of materials to be used and their effect on sound quality.

At one Audio Fair last year, we compared sound reproduced by a transistor amplifier produced by a famous manufacturer and sound reproduced by a 211 vacuum tube amplifier of apparent good quality. To my surprise, the 211 amplifier sounded exactly like the transistor amplifier! I expected more from the triode. Perhaps this was due to the use of feedback in the triode amplifier. Clearly to raise the performance of a single triode amplifier above the crowd it is necessary to optimize the design and parts quality used in its realization. It is not enough simply to use triodes.

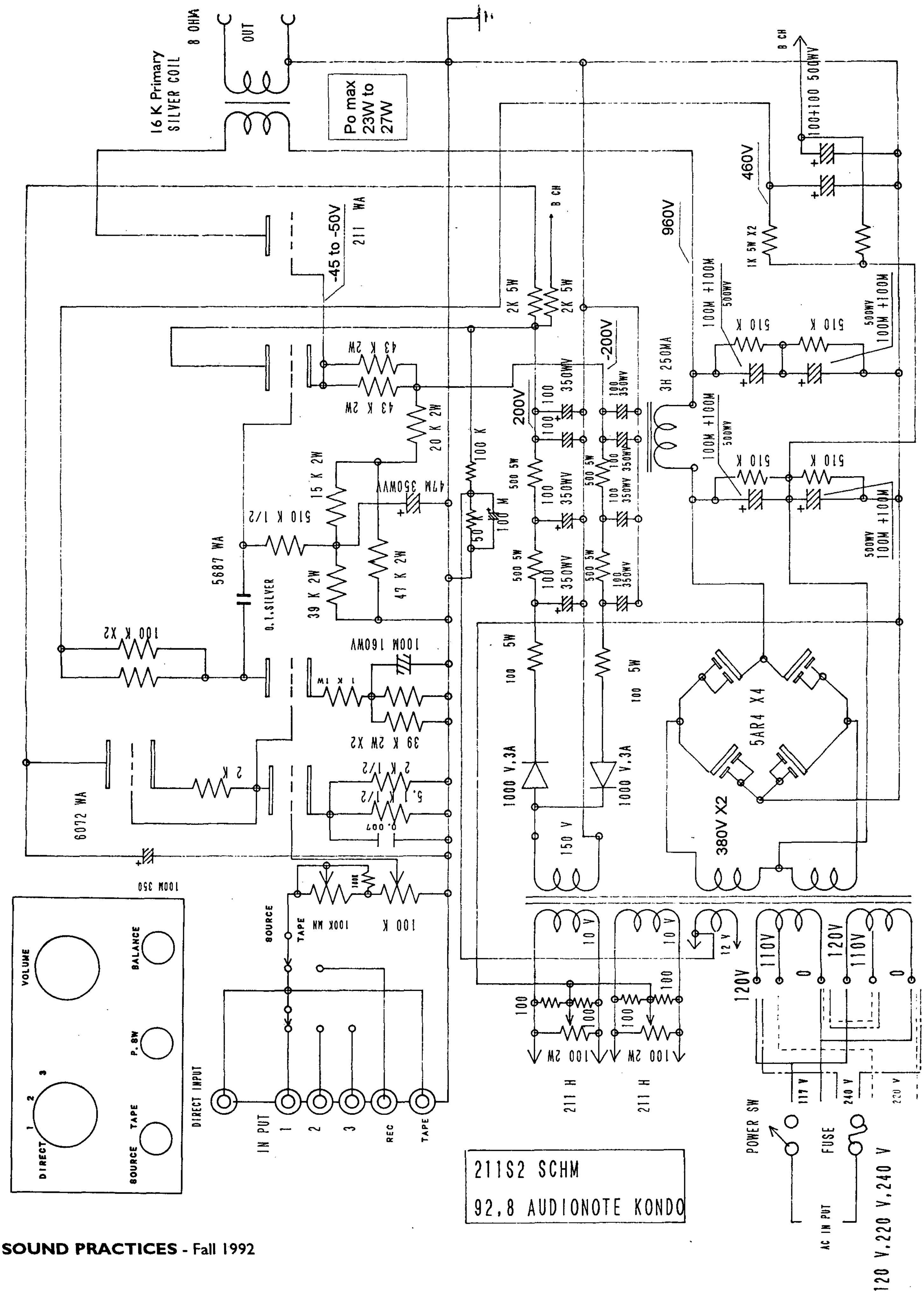
I reemphasize that it is necessary to simplify the fabrication of an amplifier and to carefully select highest quality parts in order to reproduce a "quality of live sound" free from mechanical sound. These are the most important considerations in producing an ideal amplifier.

I AM AN ENTHUSIAST FOR SINGLE ENDED AMPLIFIERS

The single type power amplifier enables greater simplicity compared with other types of amplifiers, if high power is not a requirement. Even a non-feedback single ended amp can provide low distortion with proper selection of power tubes. With the right parts, the sonic results can be excellent and we can enjoy a more dynamic sound than that produced by a higher powered amplifier. If the circuit is simplified, in other words, if the number of parts to be used is reduced even by one, the sound produced by that part, mechanical sound, will be eliminated.

It is interesting that we cannot simply say "the single type can reproduce a good sound." Some single type amplifiers can produce more distortion. Choice of tube types is important in this respect. Distortion in the power tube cannot be eliminated completely, even if the previous stage is designed for minimum distortion. Push-pull circuits can eliminate the second harmonic produced in the output stage. This is the reason why many high class amplifiers employ the P-P configuration.

However, some say that a push-pull output stage makes the sound unclear. There is certainly a potential for unclear sound in these designs due to imbalances. The current state of parts, especially the OPT, is not sufficiently advanced to avoid this problem. The deterioration of sound quality due to improper balance is a challenge for the designer to solve 30 years from now. On this basis, the single type can be recommended, since this type is free from unclear sound due to imbalance.

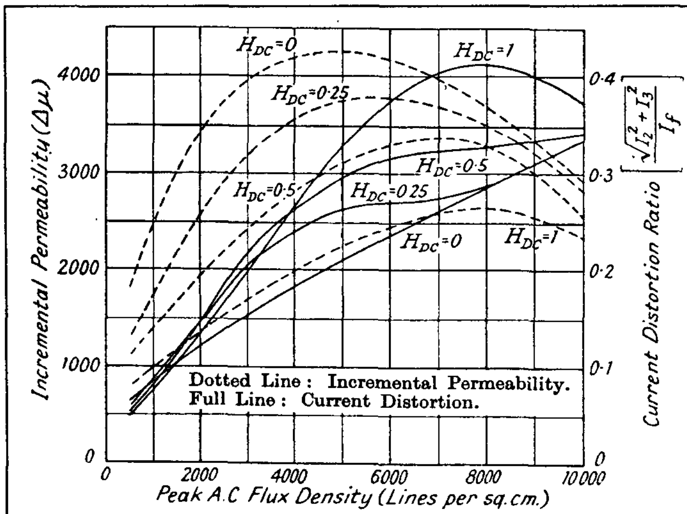

211S2 SCHM
92,8 AUDIONOTE KONDO
16 K Primary
SILVER COIL
8 OHM
OUT
Po max
23W to
27W
211 WA
-45 to -50V
6072 WA
5687 WA
0.1 SILVER
5AR4 X4
380V X2
960V
460V
200V
-200V
3H 250MA
150 V
1000 V,3A
211 H
POWER SW
FUSE
AC IN PUT
120 V,220 V,240 V
VOLUME
BALANCE
DIRECT
TAPE
SOURCE
DIRECT INPUT
IN PUT
REC

However, there is a specific challenge which the single type must overcome and we cannot say that the single type is good unless it successfully overcomes this problem. In short, we cannot blindly become enthusiasts for single ended amplifiers.

PROBLEM WITH OUTPUT TRANSFORMER

Through the single type OPT, much direct current passes. If an iron core is fixed to the coil and DC passed through the coil, the iron core will be magnetized as a result, thereby causing deterioration of the characteristics of the low end of the sound range. Magnetization may lead to low-pitched sounds not being produced at all. In order to avoid the hazardous magnetization of the core by DC, an air gap is provided in the magnetic path of the iron core. In order to enhance bass reproduction, the volume of the iron core must be increased so as to increase the magnetic flux handling capability of the transformer.

The world is as kind as it is cruel. The loss generated by the air gap brings the magnetic characteristics to a crisis (Note the hysteresis curve), thereby causing the smooth curve to be changed into a curve which is partially linear and gradually less and less linear as it approaches saturation. Actually, this action enhances the linearity of the mu (permeability) in the small signal region. The enhanced linearity in the low level signal range improves the transmission capability of small signals, thereby enabling greater clarity and detail in musical reproduction. This phenomenon does not occur in push-pull transformers.



Incremental Permeability and Current Distortion Curves Against Peak A.C. Flux Density for Normal Stalloy Core.

Editor's note: This graph illustrates the effect of DC magnetization force (H) on the linearity of incremental permeability in single ended output transformers. From Sturley, K.R. Radio Receiver Design: Part. 2, 3rd printing, Wiley, 1949. Abstracted from Partridge, N. Harmonic Distortion in Audio Transformers, Wireless Engineer. Sep., Oct., Nov. 1942 (Thanks to Dr. Tom Hodgson for this citation).

Merely increasing the volume of the iron core, i.e. increasing the size of the sectional area of the iron core, will not necessarily lead to improvements in musical reproduction. There remains the problem of the tone quality reproduced by the material of the iron core. This is the reason why our company manufactures the OPTs at our own plant. Needless to say, we carefully select the material to be used for the iron core (by placing an importance on the resolution of sound) so as to reproduce good tone quality. Our transformer employs a cut core. A non-magnetizing band is used for the core as well as a non-magnetic transformer case. We pot our transformers with 24 hours-curing type epoxy to fix the coil and core securely to avoid mechanical resonances. The wire is wound around the bobbin by hand so as to provide a proper tension in the wire. No other OPT in the world is manufactured with such attention to the resulting quality of tone.

MATCHING OF OPT AND POWER TUBE

The capability of an OPT is typically indicated in terms of low end performance, for instance, wattage that can be transmitted at 50 Hz with 3% distortion. The type of distortion introduced in the OPT is distortion of the AC signal current, a most troubling type of distortion. The level of distortion produced in the output stage varies with the relation of the plate resistance of the power tube to the load impedance reflected to the primary of the transformer. The OPT for the Ongaku provides excellent performance through the entire audio range, because the primary impedance is a very high (20K ohm) and first class silver wire is used. The size of this OPT is large beyond common sense.

This single triode amplifier displays outstanding low end characteristics when compared with other amplifiers of this type because the OPT core volume is very large. It can successfully reproduce a very soft and warm low-pitched sound. We tend to imagine that we can enhance the tone quality if we were to utilize high permeability core material. But permalloy has a weak point in that it cannot provide enough power in low notes, since it will saturate at a magnetic flux density below the operating point of power amplifiers. In order to reproduce good quality sound, we must carefully select the iron core material, carefully specify the winding method, and choose the material of the transformer wire with optimal sonic results in mind.

CONDENSERS

A coupling condenser is often necessary in vacuum tube amplifier circuits. The measurement of the internal series resistance of the condenser often shows an unexpectedly high value. This is not an exceptional case in a small capacity condenser. The cause of this problem is in the structure of the condenser.

The largest problem with the tone quality of the condenser is a "noise between electrodes" - audible energy created by the above-mentioned resistance. Once this noise is produced, the electrode-to-electrode area will produce noise continuously. It adversely affects the tone quality because of its high Q resonance. The reproduced sound will become a metallic sound or a frivolous sound just like a rubbing sound produced by high-polymer films. The problem is part electrical and part mechanical.

The problem with condensers is not limited to crude forms of distortion. We are manufacturing condensers with particular emphasis on materials in order to minimize sonic deterioration. Specifically we use a thick silver-leaf for the electrode and wind the foil by hand making sure to provide enough tension. I still remember my deep emotion when I first listened to an amplifier using the silver-leaf condenser. The tone quality of this vacuum tube amplifier is so excellent that it is unparalleled in the world. The reproduced sound is, needless to say, free from metallic sound. A very dynamic sound effect and sound approaching live sound can be reproduced. The pizzicato of low strings can be reproduced properly in time. The reproduced sound really offers "music." Although the higher cost of the silver-leaf condenser is a disadvantage, the use of this type condenser is inevitable when the goal is to reproduce a really good sound. This must be a "favorite amusement of a king."

CIRCUIT OF ONGAKU AMPLIFIER

The circuit itself is unexceptional. The 211 is driven by SRPP input stage, a common type voltage amplifier comprises the second stage and a cathode follower provides the third stage. The first stage is DC coupled to the second stage, as are the driver tube and output stages. A high supply voltage around 500V is applied to the second stage so as to ensure enough driving voltage for the 211 grid. On the third stage, the minus power supply supplies the voltage to the cathode so as to regulate bias voltage. An important feature of this circuit is its power supply circuit. A full wave bridge is constructed from four 5AR4 tubes with sections paralled to rectify the B+ supply. We use the utmost care when selecting the vacuum tube, since the performance of the vacuum tube determines the quality of sound to be reproduced.

SILVER WIRE WOUND OUTPUT TRANSFORMER

The most significant mistake of theoretical audio maniacs in this century is that they threw away the OPT. In many cases, transformers can adversely affect the quality of reproduced sound but I feel it is not correct to employ the OTL without conducting adequate experimentation and without particular attention to design considerations.

Although they say that the resolution may be degraded if a signal is transmitted through the OPT, it is a well-known fact that the transformer can offer a good feeling of the music that the OTL cannot. Accordingly, we are required to solve the problem of how to enhance the resolution of sound with OPT.

I can still remember my deep emotion when I reproduced the sound using the MC step-up transformer wound with silver wire 13 years ago. Using silver, I could successfully resolve the "problem with the noise produced by the transformer," which we could not solve up to that time in the recording studio. From that time, we began using silver wire in a wider range of applications. We finally arrived at the conclusion that magnetism matches the silver wire better than the copper wire. The performance of the silver wire used in the magnetic circuit is wonderful. The performance gives us a feeling as if a signal which once got blocked rushes forward like floodwater. We can perceive that the signal flows smoothly without binding. The work of the silver wire is especially wonderful in the small signal area. The silver wire wound transformer contributes to the enhancement of tone quality reproduced by the vacuum tube amplifier, thereby allowing the vacuum tube amplifier to become famous for its good quality of reproduced sound. In some of our amplifiers, such as the KEGON/C, copper wire is used for the primary side of the OPT to reduce cost and only the secondary is wound with silver wire.

OTHERS

The chassis of the Ongaku amplifier is made of pure copper for the purpose of enhancing the tone quality. The twin-monaural configuration is employed for the purpose of minimizing the interference between the sounds reproduced from the left side and the right side. The realization of such purposes resulted in a larger and heavier chassis. One of the reasons why the "Ongaku" amplifier won world wide fame is the elaborate execution of this amplifier.

EPILOGUE

As a result of our endeavor, the completed 211 can really reproduce "musical" sounds. It is an optimal amplifier for listening to classical music. It not only reproduces a live sound but it also allows the listeners to identify what part of the music is reproduced from what position of the equipment. For instance, when we reproduce a violin concerto, the melody played by the violin is reproduced more prominently than other sounds. In addition, the reproduced music is free from any metallic sound. We can listen to the bright vocal as if enjoying a live concert. I never saw such a highly sophisticated power amplifier before. The 211 "Ongaku" amplifier informs the listener with new life. How can we express such an excellent and majestic sound as this reproduced sound? We can only say "Ongaku!" to describe such reproduced sounds.

We must confess that it is not an easy task to master the secrets of the audio equipment!

ONGAKU FOR THE REST OF US

I don't know about you, but I sure can do without that "mechanical sound" characteristic of complicated designs. Unfortunately, an authentic Audio Note *Ongaku* is not in this year's budget. Actually, the retail price of this amp may exceed my total net worth by a slight margin - even exclusive of shipping charges. If I sell my present system, I might be able to swing a pair of those hand-rolled silver coupling caps though.

But wait . . . because Kondo-san was gracious enough to share his design with the international experimenter community, we can build our own 211SE amps based on the Kondo masterpiece. Of course, we can't build a real *Ongaku* -- part of the celebrated sonic magic of the amp is in its exquisite material execution and the special virtues of in-house Audio Note parts. But I'll bet the Kondo circuit will turn in a respectable performance even when more pedestrian materials are employed. Until the *Sound Practices* publishing empire hits the "big time", I'm afraid I must settle for second best when a savings of $60,000 is involved.

Some interesting components are available from Audio Note, UK which would be appropriate for a "Poor Man's Ongaku" project, including single ended transformers for the 211 and a line of oil/paper coupling caps. A primary mission of the Audio Note UK operation is to make some of the findings of Kondo's uncompromising explorations available to the audiophile who isn't blessed with an Ongaku-sized budget. Toward this goal, they are developing a line of lesser-priced equipment of high musical achievement along with providing a selection of music-quality parts for fellow audio adventurers.

OK, homebrewers. . . time to get those soldering irons "in the heated state", as Kondo-san puts it. Next time: my report on "Building the Poor Man's Ongaku" and more on this interesting design.

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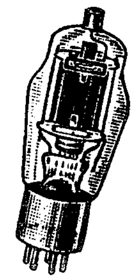


A CURE FOR TRIODE FEVER??

by Gordon Rankin, Wavelength Audio

I would like to start by mentioning an idea that has proven to be a valuable tool these past several months: Design without preconceived understandings. Why?? Well, I have been designing audio equipment for over 15 years and have listened to everybody hype their slice of pie and put down their failures. I include myself here. Lately, I have approached some "experimental" designs without preconceived biases and they have performed wonderfully.

The reason that designers have preferences in the first place is that there are things that they have tried and have had success with, and things that they haven't tried at all. Often, this or that topology or approach gets a bad name by word of mouth for no good reason. The reputation of a design assumes a life of its own apart from its actual performance. Some technologies come to bear a name, positive or negative, that is not fully deserved. Also *nobody* has tried *everything* and we have to think of reasons for sidestepping those approaches we haven't explored for one reason or another.

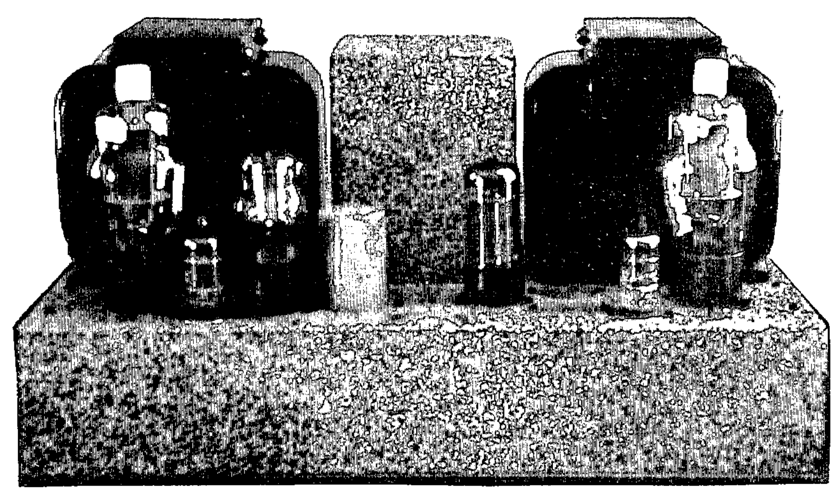
In thinking about single-ended amp designs, I wondered, "why not a PENTODE based single ended amp?" Several of my push pull pentode amps worked out great after all. In these days of TRIODE FEVER, is our loyal servant the pentode getting a bad name? Anyway, I began to wonder what a nice beefy single ended pentode amp might sound like. Nobody I know had ever heard one . . .the rest, as they say, is history.

The advantages of the pentode tube are simple. The input sensitivity and efficiency of a pentode makes it easy to design a workable simple two-stage circuit. Because drive requirements for the multigrid tubes are moderate, you could use a basic great sounding low-gain triode front end stage. And the output power would be slightly higher than your typical 300B class single triode amp without resorting to transmitting triodes and all the high voltage that involves. There is no reason you can't use, for example, two 6550s in parallel to get a respectable 30 watt power output from a single ended amplifier.

True, pentodes lack the low plate impedance of triodes but we're still talking pure Class A operation. As for the harmonic advantages of the triode, regardless of whether a single ended amp uses pentodes or triodes the second order cancellation of push pull does not occur. Could it be that the magic of single ended triode amps has more to do with the fact that they are single ended than that they are triode based? Maybe a little even-order harmonic helps out with the single pentode configuration?

When you set out to design anything, you have to declare several assumptions so that the remaining variables can be determined. For starters, I decided that I wanted at least ten watts output. This is an arbitrary figure, but I figured my ProAcs would probably like to see at least ten watts on the other end of the wire. This target was well within the capabilities of a single pentode power tube. This modest power target would help keep it simple and I would get to hear what a straightforward, high quality single pentode amp sounds like. Since it was "just an experiment," I decided to do a stereo amp with a common power supply for the sake of simplicity and to cut my losses in case of a loser.

The move away from the popular medium power output triodes - like the 300B - has powerful advantages in terms of tube availability and economy. I chose a mildly obscure (from the vantage point of high-end audio) but highly available tube, the 807. There seem to be an awful lot of 807s on the market relative to the number of products that use them. The 807 was the first and final choice for this design and it proved to be a fine selection. This tube is listed in the tube manual as a beam power tube of the tetrode variety but it is usually illustrated with the suppressor grid tied to the cathode. This is typical of pentodes so let's just call it a PENTODE and get to work.



The 70 pound / 10 Watt Wavelength Audio 807 SE Amplifier

In working with pentode amplifiers, it has become apparent to me that *some* feedback is required - whether global or local to the output section. In a single ended amp with an output transformer only 1 dB down at 30 Hz, I feel that *global* feedback would be a travesty. I was counting on (pressuring) MagneQuest to come up with an awesome design so skimpy primary inductance was not an issue. I guess if the primary inductance were on the low side, one *might* be tempted to use some global feedback to extend the bandwidth on the low end.

I planned to use a few dBs of *local* feedback through a partially unbiased cathode resistor to maintain stability. I have determined that a reasonable amount of local feedback can make an appreciable improvement in the stability and sonics of a nice pentode amp. Local feedback is created by the current going through an unbypassed or partially unbypassed cathode resistor. As stated in the *Radiotron Handbook* (p.327), "If the signal current through the [tube] and Rl (load resistor) is called i_p, then the signal voltage drop across R_k is R_k x I_p, which is proportional to the signal load; hence, current feedback." By limiting the gain per section in this fashion, the linearity is improved and the distortion can be reduced without the time domain problems of global negative feedback.

I called Mike LaFevre at MagneQuest to inquire about a custom transformer for this project. After looking at some curves and spending some time with the *RCA Tube Manual* and the *Radiotron Designer's Handbook*, we determined that the primary impedance of the output transformer should be 6000 ohms. This step is easy thanks to a very useful MAGIC equation for determining the primary impedance required for an output transformer. It can be found on page 561 of the *Radiotron Handbook*:

$$Z\ primary = 0.9(B+ / Ip)$$
where Ip = Plate current

I tried to verify this equation and, sure enough, the MAGIC number falls between 0.75 and 0.9 in every case I examined.

For a single 807, the trans would have to handle 50 to 60 ma of unbalanced DC. Yes, it would be BIG. There is a lot of wire on that 6K primary - 3028.3 *feet* of #28 to be exact. Mike chose to design it on the same core he uses for the *120 watt* Dynaco A-450 transformer - a hefty 2 1/2", 12.5 pound stack of M6 laminations. A monster.

The primary inductance would work out to be about 64 Henries giving a -1 dB @ 30hz. rolloff. Primary DCR would be 188 ohms about 70% of the resistance which would cause 1 dB of insertion loss (i.e. 300 ohms). A special winding technique would be employed in which a constant secondary resistance is reflected to the primary regardless of which secondary taps are chosen. The transformer would run at a conservative total flux density around 13.5 kilogauss.

When the prototypes came they weighed in at 20 pounds each! The cost of producing an appropriate output coil for such a design is one good reason you don't see too many single ended 807 amps in *Stereo Review*. In fact, a quality trans for this application is bigger and more expensive to create than an equivalent quality unit for a single 300B amp. Because of the higher primary impedance and somewhat higher DC and AC current, *double* the primary inductance of a good single 3K transformer like the MagneQuest FS030 is required for the same LF cutoff. So, if you go the single pentode route instead of the triode route, you'll be saving $$$ on tubes but a chunk of that gets reinvested in iron.

When I set out to design this amp I knew it wouldn't be Wavelength Audio's first major international marketplace success. Single pentode amps are a bit marginal, they're still a few years away from a category of their own in the *Audio Annual Equipment Directory*. It was just an experiment but it is one that really worked well. Surprisingly well. If you're in the market for a 60 pound 10 watt stereo single pentode amp project, I present to you the Wavelength Audio single 807 amplifier. Go ahead and build one today. ENJOY!

DESIGN PROCEDURE

For the benefit of those who are perhaps curious what goes into the design of an amplifier, let me go through the procedure I used to design this amp on a step-by-step basis. Don't be intimidated by the equations; you probably got way beyond this level in high school algebra. If you're a pure novice at electronics, but anxious to learn, read through the boring stuff a few times and some useful concepts will stick. Skim over the details but try to get the big picture.

For those of you for whom the process of designing an amplifier is old hat, relive it with me. I'm sure you'll recognize the math, minor screw-ups and late night phone calls. This may be a unfamiliar product but the same old basic logic applies.

Here is a general outline of the necessary steps: We know the power output desired, the input voltage (1V), and the nature of the load (8 ohms).

1- Determine total gain needed for the amp
  a) Calculate output voltage required for a given power output in Watts with 1V input sensitivity
  b) Determine output transformer losses
  c) Determine total gain

2- Determine gain distribution among stages starting at the output and working back toward the input. Make adjustments for available components and calculated circuit values.

3 - Set up the final working parameters on a stage by stage basis.

This would be a *very* straightforward exercise for an amp without local feedback. As it is, a few extra steps are required to set up the 807 cathode circuit they way I did it.

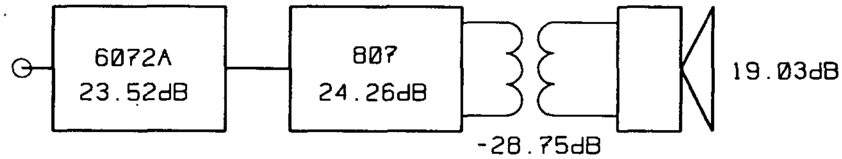


Fig. 1 - Gain block diagram of 807 amplifier

No big deal - anyway, it allows us to squeeze in a lesson on bypassed vs. unbypassed cathode resistors along the way.

THE OUTPUT STAGE

OK, we want a 10 watt amp. The output *voltage* for an 10 watt amplifier considering an 8 ohm load is:

$$Watts_{out} = V^2/R \qquad \text{(eq.1)}$$

This means that:

$$V = \sqrt{R \times Watts_{out}} = \sqrt{10 \times 8}$$

or 8.944 V across 8 ohms

To determine the total gain required, we need to know the loss of gain in the output transformer. There is a loss of voltage gain because our output transformer steps *down* voltage as it steps *up* current. It can be calculated as follows:

$$A = \sqrt{\frac{Z1}{Z2}} = \sqrt{\frac{8}{6000}} = 0.0365 \qquad \text{(eq. 2)}$$

Z1 = output impedance
Z2 = primary impedance
A = voltage gain loss

We will assume the magnetic losses to be negligible for purposes of calculation although there is some loss in practice.

With the above information we can determine to total gain required:

$$V x \frac{1}{A} = 8.944 \frac{1}{0.0365} = 245 \qquad \text{(eq. 3)}$$

We need a total gain of 245 at the output of the amplifier but we must not utilize the entire capability of the output tube because we want some local feedback. So how do we work out the gain distribution of the amplifier?

From the 807 curves, we can determine that with a screen voltage of 250V and an output impedance of 6K, the gain will fall between 10 and 30. To employ some local feedback and still get sufficient gain, I decided to *partially* bypass the cathode circuit. That way, I could adjust for the desired gain.

807 CATHODE CIRCUIT

The cathode to grid voltage at 450V on the plate and 250V on the screen is about 18V. This means that if the gain of the driver stage exceeds 18, the amp will clip at the input to the 807.

So, let's play it safe and set the input stage gain at 15 and the gain of the 807 just over 16 (15 X 16.33 = 245).

For 10W output from an 807 in Class A, a current of 50 to 60 ma through the tube is required. Therefore, the *total* cathode resistance required for 18V cathode to grid works out to be 360 ohms using Ohm's Law. This determines the DC (bias) aspect of the cathode circuit.

Now let's look at the AC (gain) function of the cathode circuit. We need a gain of 16.33 and we know that our load is 6K and the rp = 38K. By the unbypasssed equation (eq. 6), we can see that we need an unbypassed resistance of 169 ohms. So let's bypass 200 of the 360 ohm total and use a variable resistor for the unbypassed part so we can dial in the bias to exactly 50 ma.

OK, Kids, *here's the math.....*
The gain of a stage with a *fully bypassed* cathode is given by:

$$gain = \frac{u \times Rl}{Rl \times rp} \qquad \text{(eq. 4)}$$

Rl = Load resistance
rp = Internal plate resistance
u = amplification factor or "mu"

The gain of a stage with an *unbypassed* cathode resistor is given by:

$$gain = u/(1+[(rp+Rk \times u)/Rl])$$

Rk = Cathode resistor (eq. 5)

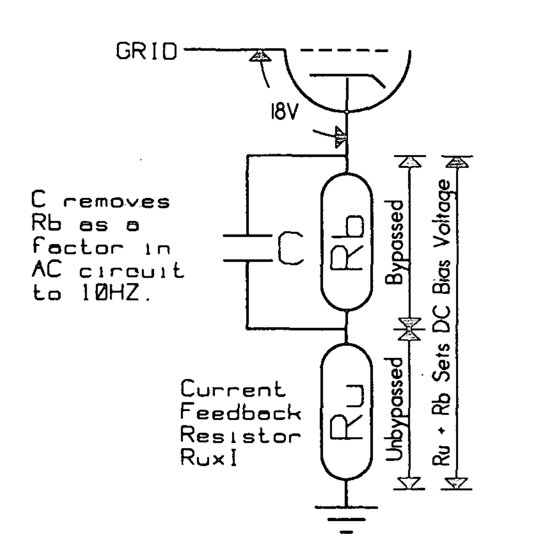


Fig. 2 - Functional 807 cathode circuit diagram

At 450V B+ and current of 50 ma, the transconductance of the 807 is 5850 umhos and the Rp is 38K so the mu works out to about 222.

Rearranging the unbypassed cathode gain equation (eq. 5) we get:

$$Rk = [(u/gain)-1 \times Rl - rp]/u \qquad \text{(eq. 6)}$$

Next we calculate the bypass cap value. The bypass acts like a dead short to AC down to a particular frequency depending on its capacitance. Below this frequency it will cause a loss of gain. I chose 10 Hz for this single ended amp as the -3 dB point for the bypass cap. 3dB down from 16.33 is a gain of 11.55 at 10 Hz - i.e., 0.707 X 16.33.

Plugging 11.55 into eq. 5, we see that the value of the unbypassed Rk should be 323. Since the unbypassed portion of the cathode resistance required for a gain of 16.33 is 169 ohms, we subtract that figure from 323 to find the reactance we need at 10 Hz.

The total reactance (the capacitors impedance in parallel with the 200 ohm resistor) is 154.4 ohms. We need to calculate what part of this impedance comes from the 200 ohm resistor and which part comes from the capacitor - in other words, what impedance in parallel with 200 ohms will give us 154.4.

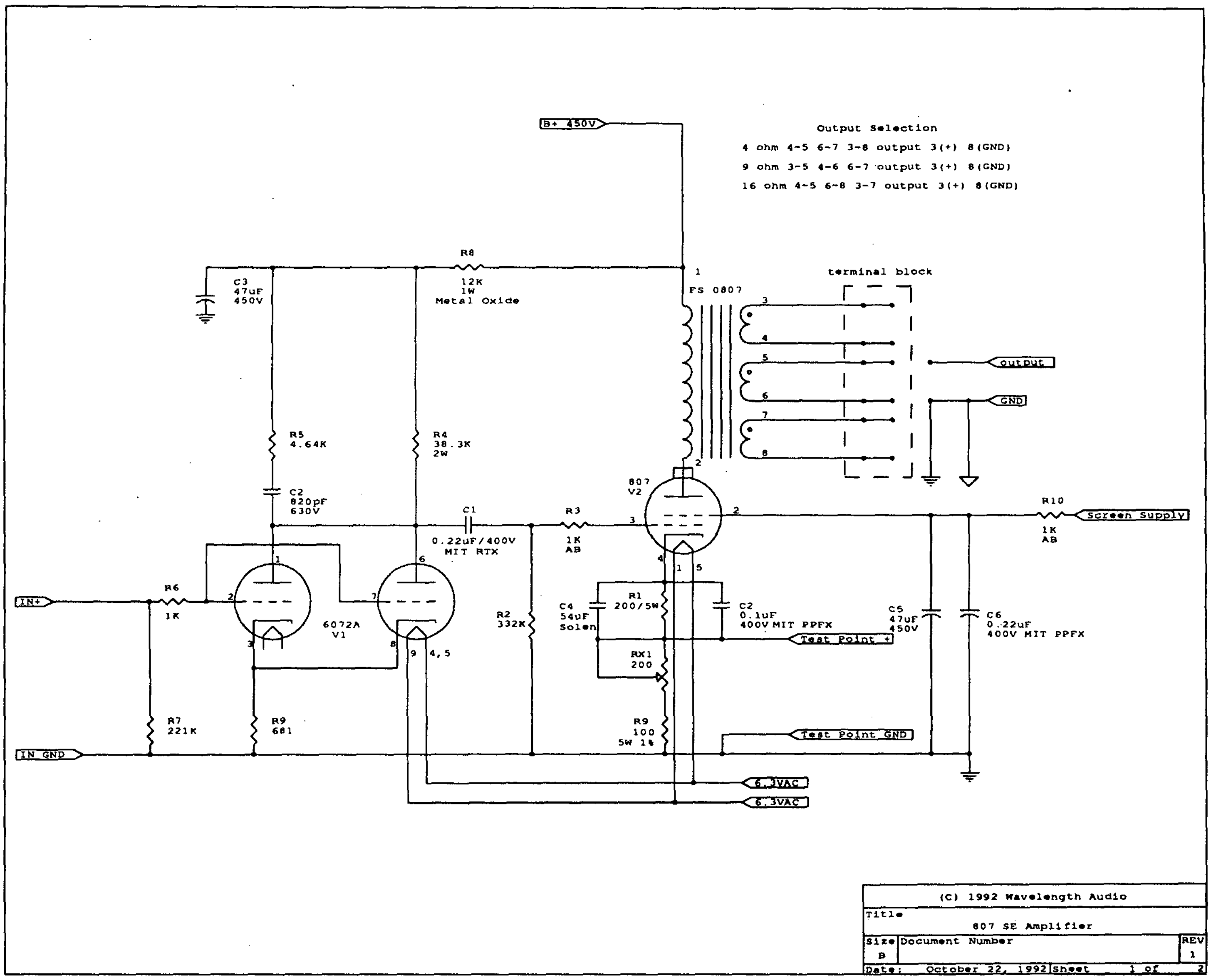
$$\frac{1}{Z} = \frac{1}{R} + \frac{1}{Zc} \qquad \text{(eq. 7)}$$

We end up with Zc = 680. At 10 Hz that requires a capacitance of at least 23.4 mF. We know this from the formula for capacitive reactance. This formula tells us what size cap has a reactance of 680 ohms at 10 hz.

$$Xc = 1/(2\pi fC) \qquad \text{(eq. 8)}$$

In my amp I used 24 mf, the nearest standard value to 23.4 mf.

The output section is now completely designed with a cathode resistor of 300 fixed and 200 variable, 450V on the plate, 250V at the screens, and an output transformer with an impedance of 6K. We have 5.56 dB of local feedback on this stage. The tube manual says that an 807 in self bias can have a maximum grid resistance of 0.5 megohms. I decided to use some 332K HOLCO units I had on hand as the in-



put resistors. It's a good idea to use a value that is at least 20% less than the maximum permissible value. That pretty much completes design of the output section.

THE INPUT STAGE

Now let's take a look at the input section. We need a gain around 15 to 18 with good noise immunity and enough drive to carry the 807 - with a 332K on the 807 grid, that's not a whole lot.

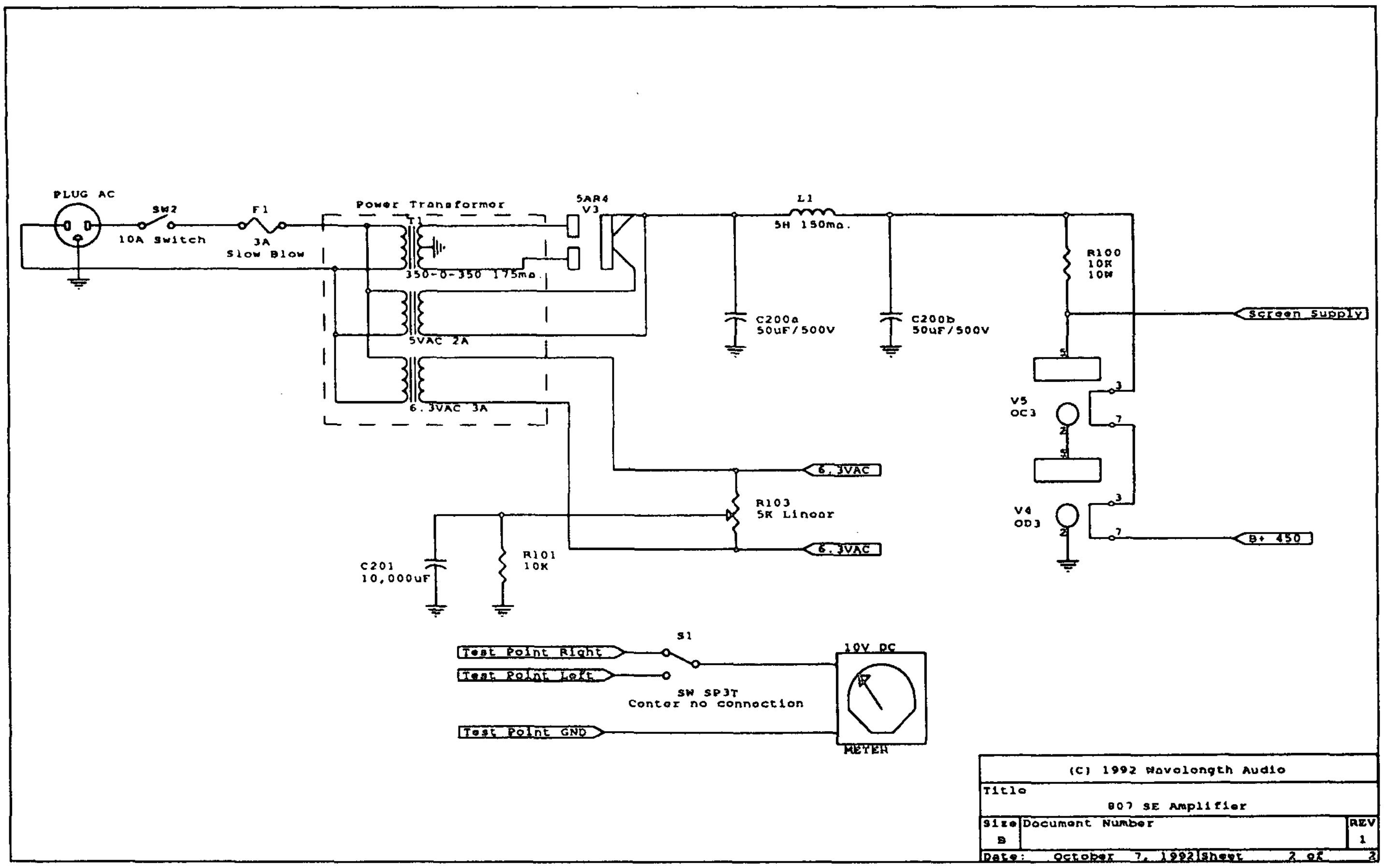
If we look at the dual triodes in the tube manual, we find units with mu of 20, 40, 60, and 100. 20 is too close to the needed stage gain to give any headroom and 100 is much too high to keep the gain below 18 without employing *lots* of feedback to reduce gain.

So we are left with the tubes with mu of 40 or 60. Although some designers love 'em, I haven't had much luck sonically with the 12AT7 family.

Anyway talking with a certain editor, the subject of the *Ongaku* came up. I said to myself, "Hey, what about the 12AY7 series?" The 6072A, the industrial version of the 12AY7, used as the input tube of the *Ongaku* is a particularly attractive specimen and it is readily available from distributors of NOS tubes. It has an average mu of 44 and a max. plate dissipation of 1.65W per section. We will be using the 6072A at 2.5 ma per plate and a plate voltage of 200V. We can parallel the filaments and run the tube on the 6.3 VAC tap of our power transformer.

By using the two halves of the input tube in parallel, we benefit in several ways: the rp is cut in half so the stage gain increases accordingly and noise is cut in half. Both attributes are desirable in the front end of a good amplifier. The 6072A is controlled for low noise and low microphonics so it's a natural for this application.

I set the operating point of the 6072A per the gain required of this stage. We'll run this stage at around a 400V supply so that we can use a readily available 450V decoupling cap (C3). The 6072A is running at 2.5 ma per side or 5 ma total. And we need a cathode to grid voltage of at least 2.5 to 3.5 V to provide some headroom so that we don't clip the input signal. With three volts on the grid and 2.5 ma plate current we are looking for a plate voltage of 200V. At 5 ma for both sections, a 681 ohm I had on hand used as the cathode bias resistor [R9] would give us 3.4V on the grid. Given that this resistor is unbypassed, we get 3.8 dB of local feedback in the input stage.



The load resistor (R4) is determined by the fact that we have a stage voltage of 400 and we want about 200VDC on the plate of the 6072A. I chose a Roederstein MK8 38.3K 2W metal film for this application since 38.3K x 5 ma + 200V = approx. 400V. If we plug this into the handy unbypassed gain equation mentioned above:

$$gain = u/[1 + (rp + u \times Rc)/Rl]$$

The result is a little more than 18.7 (Rl is equal to 38.3K in parallel with the 332K input resistor of the 807 because the coupling cap has negligible reactance at signal frequencies). Well, 18.7 is a little more gain than we would like but there will be other losses in the circuit due to tube and component variations and some loss in the output transformer.

The compensation network (R5 and C2) is useful because the amplifier will overshoot somewhat without it. As far as I know, this type of network was first seen in Williamson type amplifiers. I picked this trick up at Erno Borberly's suggestion. He gave me some basics on it and this is what he told me: set Rx = Rl x 0.12. The value of C is determined by running a 1 KHZ square wave through the amp (terminated with an 8 ohm dummy load) and increasing the value for the best looking wave. An 820 pf worked great with the 4.64K resistor I used. A 1000 pf cap caused the leading and trailing edges of the square wave to round off a bit. A 680 pf cap had a bit of overshoot at both ends of the square wave.

POWER SUPPLY

The power supply is all there is left to design. With the 807 cathode current at 60 ma per channel, the driver tubes running at 5.3 ma each, and a VR (voltage regulator) tube current of 20 ma we're in the ballpark of 150 ma. I chose a power transformer rated at 175 ma. If you wanted to run separate screen supplies, a 200 ma transformer would be a better choice.

We need a B+ of 450V and the 5AR4 drops about 37V. A 350-0-350V transformer will work fine. Actual voltage under load was 461V. By the way, the new Russian-made Sovtek 5AR4 is a promising replacement for the ever more scarce Mullard classic version. The voltage drop is about the same as the original, the warm up is a bit faster, and it sounds pretty good. The latest version of this tube is the first "production series" and quality is better than in some of the prototypes which were circulated earlier.

A little spot on VR tubes is probably in order, since you don't see them too often these days. In fact, I had a little trouble finding some practical information about VR tubes. For instance, I was curious about the purpose of the wire between pins 3 and 7. I thought that maybe the B+ through this wire helps the tube to fire. A call to a man of infinite tube lore, Ned Carlson of Triode Electronics, yielded the correct answer. This feature ensures that the VR tube is running: if the tube is broken, removed, or open the B+ is interrupted to save the circuit. When using VR tubes, make sure that you have a good deal of current running through them to ensure good regulation. In pentode circuits, the screens must have a stable source, otherwise the bass will suffer. The OD3 glows a beautiful luminescent purple when in operation and it makes an excellent conversation piece.

DOWN TO TWEAKING

Enough MATH! Let's get down to the components. I'm a tweaker and will always be. I have spent hours listening to cable, resistors, and caps and I decided I like HOLCOs best overall. I am using AB 1K carbons as grid stoppers and one Roederstein because of the high wattage. The 5 W cathode resistors are all Clarostat 1% low inductance wirewound types and the trim pot is a 3W multi-turn Spectrol unit. All other resistors are HOLCO half watters (H4s). The film caps are MIT PPFX except for the 820pf which is a MIAL and the large value caps which are Solen FastCaps. I really like the PPFX and the only thing better that I have heard is the RTX at more than twice the cost. Internal wiring was Kimber Kable TCSS 20 ga except for a piece of Cardas Twinax for the input lead.

A short digression on component vendors here. Listen, don't just sit around designing stuff and calling experts like Ned at Triode *every* time you can't figure something out. Get a library and study! If you do need some advice then at least buy something. These people aren't just sitting around waiting to answer questions they are in business and need to pay the bills. Advice from educated vendors shouldn't come cheap. They must study, tinker, and test with the best of them and their insight is usually hard earned indeed. Enough said.

With every project comes a unique problem. Seldom does a new product work out perfectly the first time. With this amp I had an oscillation problem in the right channel. Both channels were exactly the same. I swapped everything, including output transformers. Finally, I shorted the input and it came up fine. The problem was that the shielded input cable ran near some of the output transformer wiring and it was picking up some of the output and looping it back to the input. It was a twinaxial cable with the shield ungrounded - OOPS! Terminating the shield at the input end fixed that one -- not without 10 hours of goofing off though. Live and learn. Let's play music.

OK, WHAT ABOUT THE SOUND?

I was really curious to hear this amp since it was my first single pentode amp. My system is a Wavelength Audio Control Panel preamp fed by a heavily modified Phillips 680 CD player using a Sony DTC-700 DAT as a D/A. Phono stage is a LINN Basik with the Basik Plus arm and the K5 cartridge to a homebrew pre-preamp. Speakers are the fabled ProAc Response Twos. In short, this is a modern high-end type system. Not a pair of *Klipschhorns* or something.

My first listening was done on a pair of Wharfdale Diamond IIIs I use in the lab. Hmm, sounds pretty powerful but the lab is small. Power out measured 8.9W out before clipping. I tweaked the compensation network and took the amp out to my main system to fire it up for serious listening.

Wow, this amp can really play loud! The highs were super clean and it was the quietest tube amp I ever built. The bass was real tight but lacking in the last bit of punch in the low end. Putting in on a scope, I found a -3dB point of 40 Hz at the low end and it was good out to 50 KHZ. There was a phase shift of about 25 degrees at the low end. Not bad but I thought I could get the low end response down a bit more.

I increased the value of the screen bypass cap and that brought the power up to 10.2 watts. After some measurements, I realized that the variable resistor was set to 10 ohms not 69 as calculated. Therefore, I needed a cap of *over 50 mf* to bypass down to 10 Hz. I put a 30 mf cap in parallel with the existing 24 mf unit and that brought the -3 dB point down to 22.6 Hz. That's more like it. Still had 25 degrees phase shift at the low end.

I was amazed at the subjective performance of the amp. My ProAcs are only rated 86 dB @ 1 watt sensitivity and the manufacturer recommends a *minimum* of 100 watts. But this 10 watter can really crank! The amp had excellent bass definition and extension, with my speakers at least. Maybe separate screen supplies would *really* spice up the bass region. One could argue that screen regulation is much more important than plate regulation and VR tubes are certainly *not* the last word in regulation. But I can't argue with the sound I got with the setup I used.

I was actually surprised that the amp worked so well with my regular system. I thought I might have to get a pair of more efficient speakers to audition the amp. A pentode amp with no feedback will have a relatively high output impedance so it is rather sensitive to the choice of speaker. The measured output impedance was 1.16 ohms @ 10KHZ. By comparison, my modified Dyna ST-70 measures 0.105 ohms Z_{out} @ 10 KHZ. A stock ST-70 would be even lower since it runs more global feedback. It surely didn't hurt that my ProAcs are a pretty solid 8 ohm load, dropping only down to 6.4 ohms at 300 Hz. I honestly thought that the 807 SE was the best driver I heard for this speaker.

I'm not much good at describing my listening experiences in flowery prose so I headed down to the local high end store, Audible Elegance, for fieldwork. We hooked the 807 SE up to a pair of Thiel 1.2s, 86dB efficient two ways. The listening team thought the unit sounded especially clean without any of the hum, noise, or excesses of vintage tube gear. However the low end was seriously lacking. I would attribute this to the fact that the output transformer was strapped for 8 ohms and the Thiels are 4 ohm speakers which may drop well below the nominal impedance.

Rather than rewiring the amp, we switched over to a pair of LINN Nexus II which are rated at 8 ohms. The amp was much happier and so were our ears. No heart stopping bass but it did provide full robust low end performance. Jeff, the resident tube expert, was quite surprised that a single ended unit succeeded so well in a full range capacity. We speculated that maybe bi-amping with a push-pull amp on the lows would really open up the sound. The midrange and highs were very engaging. A few remarked that it was the most 'tubey-sounding' amp they had heard recently and it was meant in a complimentary way. Someone commented that modern tube amps had lost much of the musicality which was once the special thrill of the vacuum tube amp. The dimensional presentation of the amp was excellent indeed with superb '20 foot past the back wall' resolution of depth.

In short, the overall consensus down at the store was that the amp was quite an impressive performer *with the right speaker* and that it might be a real giant killer in a bi-amp system with a push-pull amp handling frequencies below 100 Hz. My experience with the Thiels seemed to confirm the obvious rule that it is a good idea to ensure that the output transformer is configured for a good match with your speaker.

I would say that the 807 SE amp was a successful experiment. The sonic results far exceeded my expectations. As a designer, the 807 SE provided one more good argument for keeping an open mind and exploring new directions. As an audiophile, the 807 SE is giving me some really nice sounds from a product I wouldn't have taken seriously only a short time ago.

REFERENCES

Langford-Smith, F., *Radiotron Designer's Handbook - Fourth Edition*, 1953.

RCA Tube Manuals - various editions.

POINT TO POINT TEFLON CIRCUIT BOARDS

by Mike VansEvers
Clarus Recording Products

A step-by-step procedure for easy to make, premiere quality circuit boards with all of the advantages of point-to-point wiring and none of the drawbacks of ordinary etched copper boards.

Teflon is a great material for making homebrew circuit boards. It is very soft, so it is easy to work with and using the method outlined below, no nasty chemicals are required. But the best reason for teflon boards is the same reason that teflon film caps are arguably the best audio capacitors (see refs 1-4). Teflon has an extremely low dielectric absorption factor. What this means is that teflon caps smear audio signals less than any other type of cap. By now you're probably asking yourself: "What does this have to do with circuit boards?" Quite a lot actually.

A typical copper clad circuit board acts like distributed-network small-value capacitors between all metallic current carrying objects located on it. The definition of a capacitor is two conductors separated by an insulator. Two forks separated by a napkin is technically a capacitor and can be used as one, although not easily and no claims are made for the sonic merits of this design (some prefer spoons...). Because of the high impedances found in vacuum tube circuits, even small value capacitances are significant. Subjectively, the same circuit on teflon (vs. fiberglass, phenolic, etc.) will pass more low level information, enabling you to "see" further into the sound stage.

I first heard about the use of teflon as circuit board material in a pizza parlor in the late Eighties. Not just *any* pizza parlor but the home of the BEST pizza in this spiral arm of the galaxy, Cesare's New York Pizzaria in Tampa, FL. And my guru was not just any hungry audiophile but John Beaty who, along with Mike Moffat, ran THETA - one of the leading tube equipment manufacturers of the late Seventies. Since that memorable meal, I learned that David Berning also champions the use of teflon boards. Spectral's preamps, Theta Generation 3, and John Curl's Vendetta use teflon boards. A growing number of companies, including Mark Levinson, offer teflon boards as a rather expensive option in some of their products.

I have built two sets of monoblock tube amps, a tube stereo power amp, and two pro/audiophile tube microphone preamps on teflon boards. Some traits these products all share is excellent detail and openness.

When a friend rebuilt his trusty Vorhis Last PAS preamp onto teflon, he didn't talk about anything else for at least two weeks. The rest of us quickly became sick of listening to him brag about his damned phono stage. Listening to it was another matter entirely. The sound stage had become much wider and deeper and instruments had more definition and "air" around them. It was truly a major step forward. . .but please don't tell him that I said that because I'm sure I have to hear about it all over again.

Eggs, water, dirt, magic markers, you name it, it won't stick to teflon. Most glues don't either. Therein lies the rub: attaching copper to teflon isn't easy or cheap. Fiberglass is MUCH easier to attach copper material to and much more economical. Fortunately, we don't want a conventional etched copper circuit board. For tube circuits, point-to-point wiring is much better: layout is often simpler and the above-mentioned distributed capacity problems are lessened. Our alternative method will be a *point-to-point circuit board* built on teflon, the best of all possible worlds. No noxious etching chemicals are required and the questionable audio quality of etched conductors is avoided.

As an electronic material, teflon has many advantages but it does have some mechanical shortcomings. Teflon is not very rigid - almost frozen cream cheese comes to mind. Where 1/16" fiberglass works you will need 1/4" of teflon. You can get away with thinner teflon stock for totally passive or solid state circuits. But installing and removing tubes from their sockets applies a lot of shear force and could easily tear up a thin (< 1/4") teflon board. The right teflon for tube circuits gets pretty expensive because it is sold by weight. Tampa Rubber and Gasket sells 1/8" teflon for about $20 per square foot. Quarter-inch teflon sells for four times as much, or approximately $80 per square foot. The smallest piece of teflon Tampa Rubber and Gasket likes to sell is 4" X 4" but suppliers will often have smaller leftover pieces which they will sell at a better price. A square foot will make quite a few preamp or power amp circuit boards and the improvement in spaciousness and "air" is certainly worth it. And you will save a few bucks and a small piece of the environment because etching supplies aren't needed.

As an alternative to making the whole board of teflon you can use insulated standoffs using teflon. However, in high impedance tube circuits proximity to the chassis can create adverse effects. Small capacitances to ground in lots of places can add up to a big high frequency rolloff. The best strategy to prevent excess capacity to ground is to mount the board over a cutout slightly smaller than the board.

Here are the steps I follow for making my own teflon circuit boards:

1) Make an initial estimate of the size your circuit board should be. Determine where standoffs or other mounting hardware will be placed. Some layout considerations to keep in mind:

a) Keep input wires/components at least 1-2" away from output wires/components. If you can't arrange this, orient them at right angles or place a grounded wire or shield between the input and output wires/components that can't be properly spaced. Strange high-frequency oscillations may occur otherwise.

b) Leave room around tubes, plate load resistors, and other parts which will get hot for air cooling and to keep from overheating adjacent parts. Do not position large coupling caps or electrolytics next to tubes. A minimum spacing of 3/4" is recommended.

c) If your project requires two identical circuits (e.g. a stereo preamp) lay them out exactly the same way! This will keep stray capacitances equal and ensure identical behavior across the entire bandwidth of the circuit.

2) Lay out the circuit and its boundaries on graph paper. Use one color for the components and another color for the connecting wires. A black dot, 1/8" to 1/4" from the body of axial resistors and caps, should be drawn on the layout to signify where the components lead passes through the board. Radial components can have leads pass through the board directly under the component or you can bend the leads out to any desired spacing. Place black dots at hole-centers where mounting hardware and tube sockets will require drilling.

3) Place the actual components on the paper template to verify that your spacings are correct.

4) Juggle the size of the board and component placement until all components fit properly and layout is optimized.

5) Cut out the layout template and tape it to a piece of teflon of the desired size.

6) Push an awl or other sharp pointed tool through the black dots made in step #2 to make an indentation in the board material which can be seen after the paper is removed.

7) Use a 1/16" drill bit to drill holes for all components. Use *only* paddle bits (flat wood bits) for drilling tube socket holes (3/4" paddle bits for 9-pin sockets). Be careful, though. If you get sloppy and let the bit wobble too much, you'll drill away the material you intended to mount the socket on. A 5/32" drill bit is just about the right size for drilling holes for #6-32 mounting hardware including an appropriate fudge factor. A 1/8" bit is a good choice for 4-40 hardware for mounting 9-pin sockets.

8) Install eyelets. Eyelets are not strictly necessary but they are a nice option. They are good mechanical anchors and allow the use of recycled components with short leads.

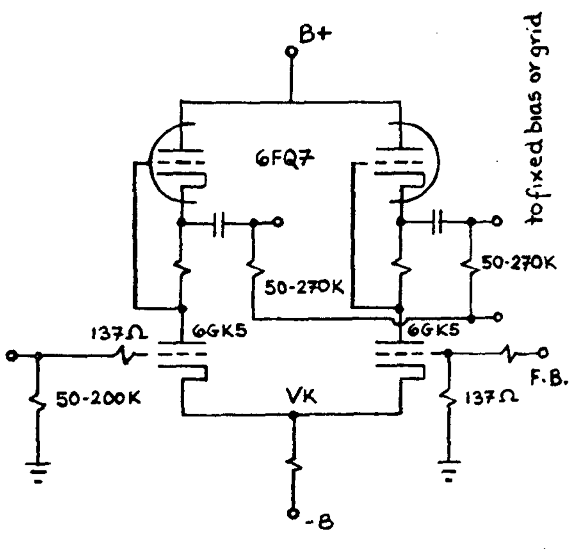
9) Install components. Use component leads to make connections whenever possible rather than jumper wires. When not feasible, use your favorite small diameter (less than 20 ga.) hookup wire and WRAP IT AROUND the component lead no less than 270 degrees. 360 degrees is even better. A good mechanical joint is essential for a good electrical connection. Make it so that it would be a solid contact even if you forgot to solder the joint.

10) Hook the completed circuit board up to the rest of your project and enjoy.

NOTES ON THE SAMPLE CIRCUIT

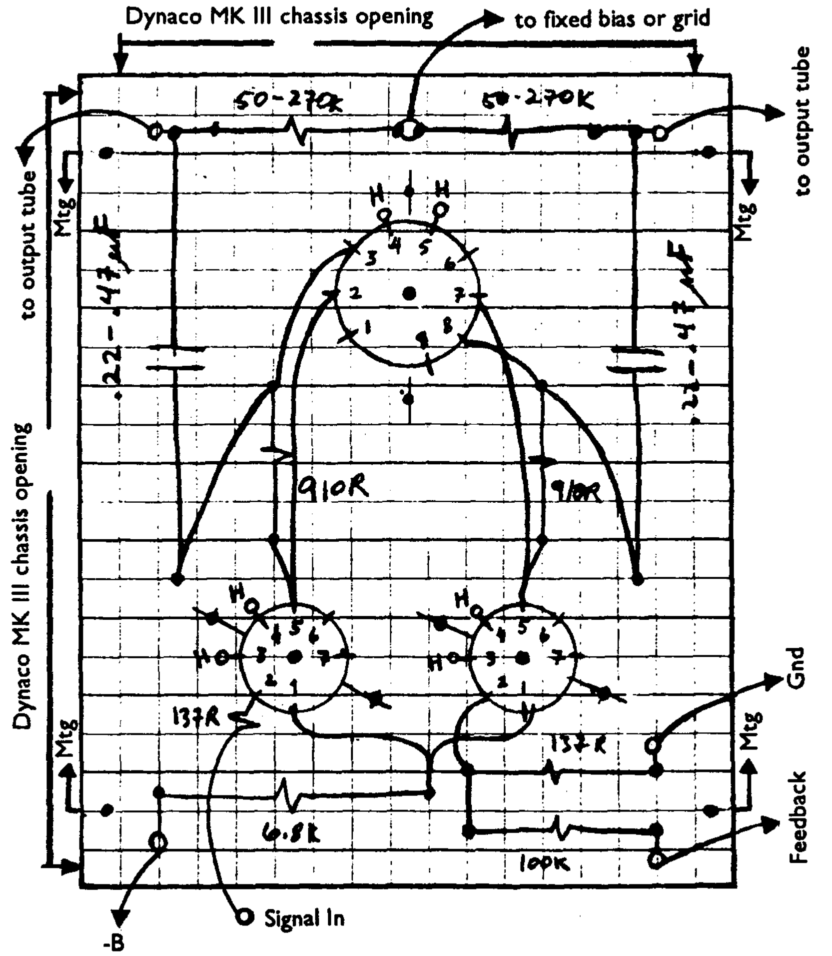
The boards pictured here were built by a friend for use in a Dyna MK III. It is a good sounding driver stage suitable for a wide variety of push-pull applications, including all of the popular pentode outputs and triodes like the 300B, 2A3/6B4-G, etc.

The 6GK5 is a 1960's design very low noise high mu triode designed for VHF applications. One could use all 6GK5s in the diff amp but then the coupling caps won't fit on a MK III sized board. The dual section 6FQ7 was employed as a space saving measure. Distortion figures are for the circuit given below. With all 6GK5s,



Here's a useful circuit: a SRPP differential amplifier driver stage.

B+ = 390 V, B- = -112V, Vk = 1.5V, Rl = 49.5K	
GAIN = 26DB	Z out = 2K Ohms
PEAK TO PEAK SWING	%THD
20 Volts	0.07
40	0.17
60	0.34
80	0.61
100	1.05
120	1.66



This is a layout to scale for a Dyna MK III driver board the B+ is 350V and the output impedance is 1800 ohms. This circuit would also be useful for converting single ended preamps to balanced output.

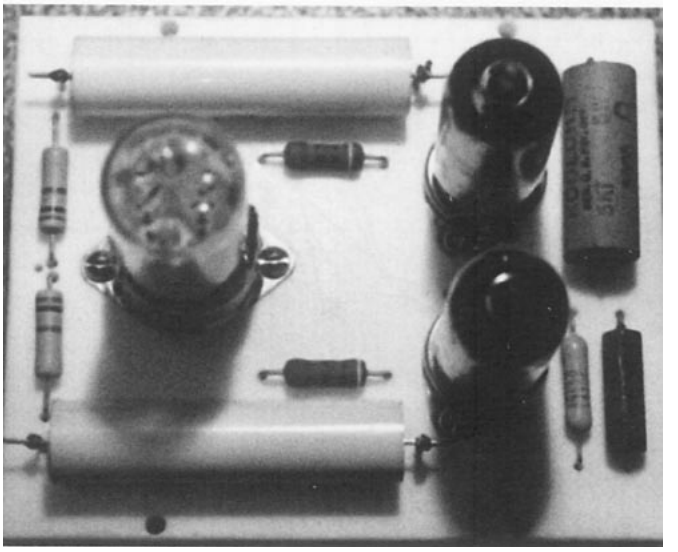
This article is really about making boards. However, if you are interested in giving this circuit a try in a Dyna or elsewhere, I can provide a collection of tube data and other application notes. Please write me c/o Clarus Recording Products at the address below and include $3.00 with your request to help cover copying and mailing costs.

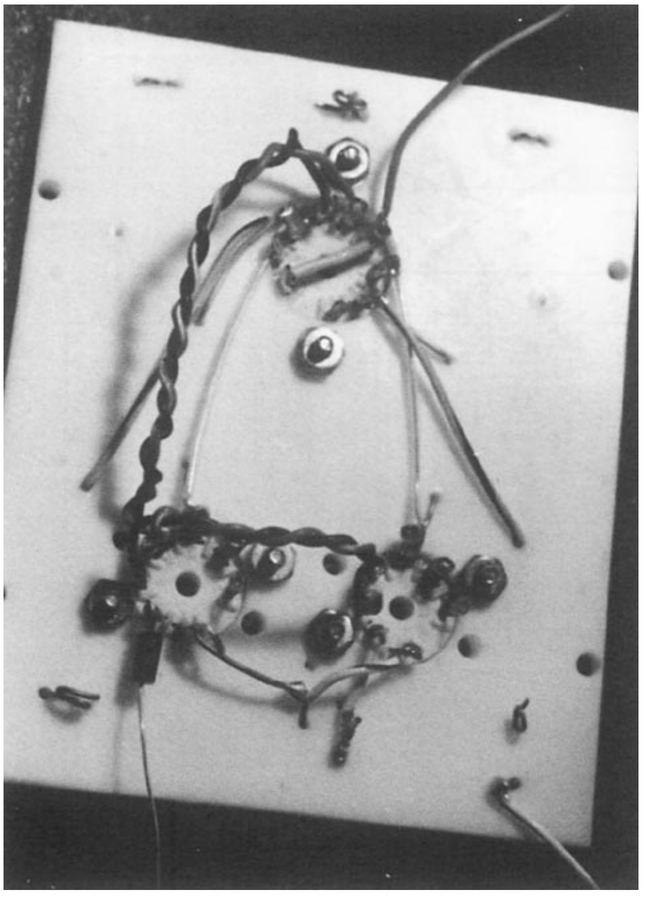
REFERENCES ON TEFLON CAPS

1. Jung, W.G. And R.N. Marsh "Picking Capacitors, Parts I & II", *AUDIO* February and March 1980.
2. Curl, J. and W. Jung, "A Real-time Signal Test for Capacitor Quality", *THE AUDIO AMATEUR* 4/85
3. Component Research, Inc., *Selection guide*, EEM, Hearst Business Communications, Inc., 92/93.
4. Pease, R.A., "Understanding Capacitor Soakage to Optimize Analogue Systems", *ELECTRONICS WORLD + WIRELESS WORLD* October 1992.

WHERE TO GET TEFLON

To find a local Teflon supplier check your local phone book under "Gasket Supplies". "Teflon" is a trademark of Dupont, Inc.





Two views of completed MK III driver board illustrating construction techniques discussed in text.

[Photos by John Conarton]

APPENDIX - USEFUL RESISTOR DATA

TYPE	LEAD SPACING	WATTAGE		MAX V	TC
RN55	1/2"	0.125	*	200	25-100
RN60	5/8"	0.25	*	250	25-100
RN65	7/8"	0.50	*	300	25-100
RN70	1- 1 1/4"	0.75	*	350	25-100
RN75	1 3/8"	1.0	#	500	25-100
RN80	2 9/16"	2.0	?	750 ?	25-100
Vishay					
S102K	0.150"	0.4- .6	*+	300	1.5
S102C	0.150"	0.4- .6	*+	300	2.3
VTA54	1"	0.5	*	300	8.0
Holco H4	9/16"	0.25	*	300	5-100
Resista MK2	1/2"	0.6	@	350	50-100
MK4	7/8"	1.0	@	500	50-100
MK8	1"	1.5	@	500	50-100
Caddock					
MK120	0.150	0.5	#	200	50
MK132	0.200	0.75	#	400	50
Hymeg HN-2	3/4"	0.60	*	1000	25-100
1W Flameproof	3/4"	1.0		350	200
2W Flameproof	7/8	2.0		350	200

NOTES:

Temperature coefficient (TC) in parts-per-million per degree C

* Military rating at 70 C, usually half of commercial rating

\+ 1-100 k ohm are 0.6 W, >100-250 k ohm units are rated 0.4W

\# Rating for 125 C ambient

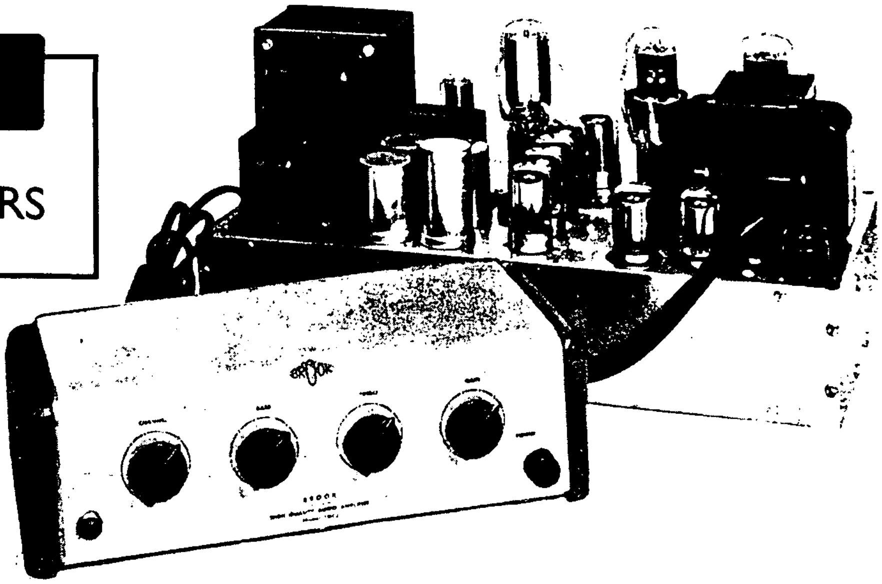
@ Commercial 70 C rating

THE AUTHOR

Mike VansEvers is trained in Geology but prefers rock music to the igneous variety. He builds and modifies microphone preamps, signal processors, and other recording studio equipment for Clarus Recording Products in Tampa. At present, he is researching noise in audio systems and he welcomes communication on this topic. You can write to Mike c/o Clarus Recording Products at 1248 E. Hillsborough Ave., Suite 200, Tampa, FL 33611.

CLASSIC DESIGNS

THE BROOK AMPLIFIERS



The Brook amplifiers were landmark products in the evolution of audio. Designed in 1947 by Lincoln Walsh, the 30 watt Brook 10C and the Model 12A, its lower powered sibling, were among the finest amplifiers available at the dawn of the Hi-Fi era in the years after WW II. There was also a Brook integrated amp (Model 22A) based on the 10 watt 12A circuit.

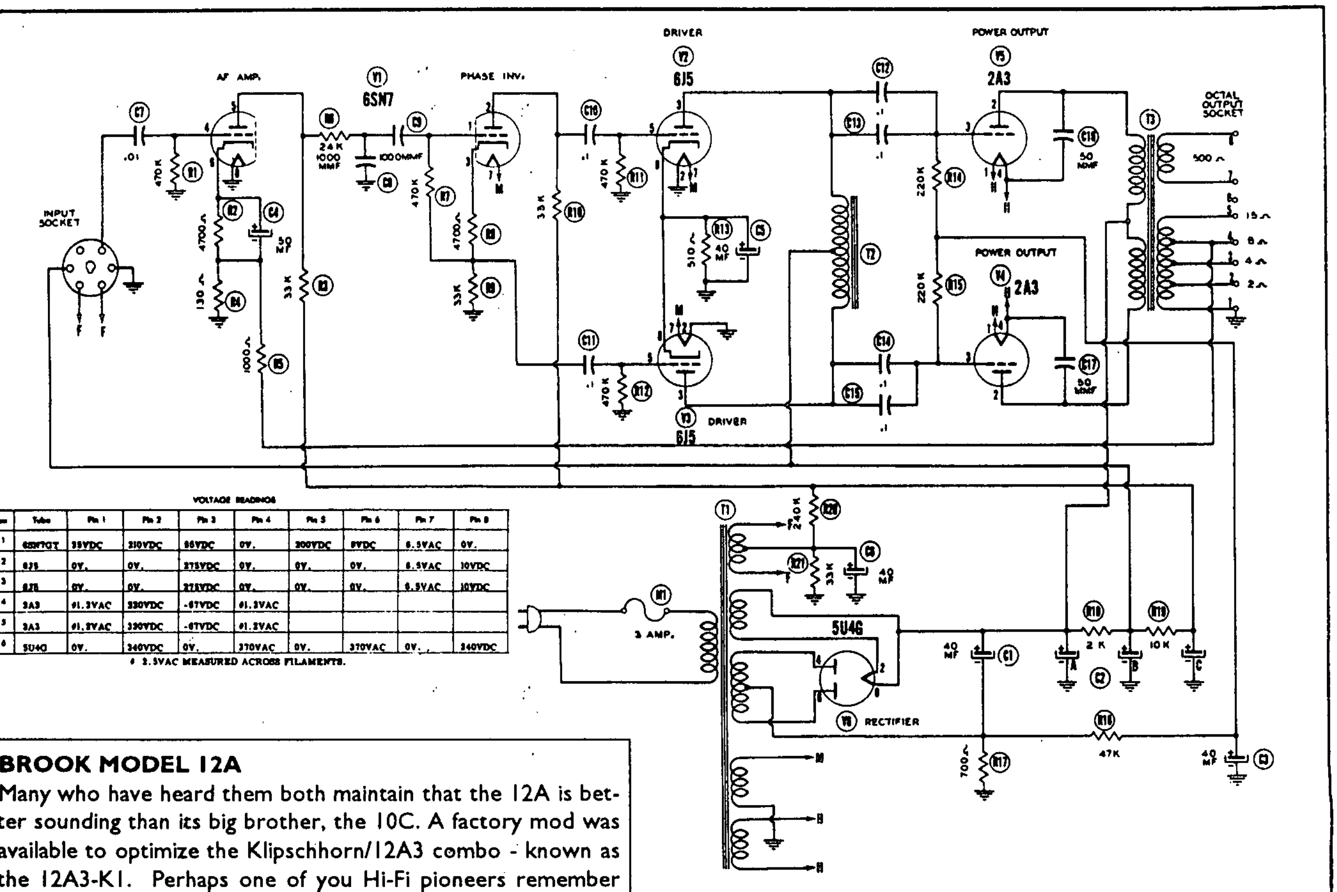
A Brook and a Klipschhorn or JBL horn system would put you in the Editor's Choice circle back in '51. The Brooks were Paul Klipsch's reference amplification.This was High End before there was High End. The Brooks are still favorites among collectors and discriminating listeners of vintage gear.

Lincoln Walsh clearly recognized the importance of proper design of the driver circuitry in a high quality amplifier. The driver in the 10C is configured as a transformer coupled cathode follower for a low impedance source of grid drive. Note that the transformer is shunted by high value caps for extended low frequency response, a tactic later employed in the Fisher 50A. Brook amps use fixed bias supplies for maximum output and low measured distortion.

he 10C features a novel automatic bias circuit patented by Walsh before the war. Varying the grid bias of the 6J5 cathode follower driver effectively controls the gain and load impedance of this tube in response to changing signal conditions - maximum gain under class A operation and lower impedance and gain under conditions of grid current. For further reading on the 10-C, see "High-Quality Audio Amplifier with Automatic Bias Control" in *Audio Engineering*, June 1947.

The Brook marketing campaign clearly targeted the "Triode Freaks" of the day. As the sales literature for the model 22A put it: "Low mu triodes, employed exclusively in the Brook amplifiers, are used

(continued p. 20)



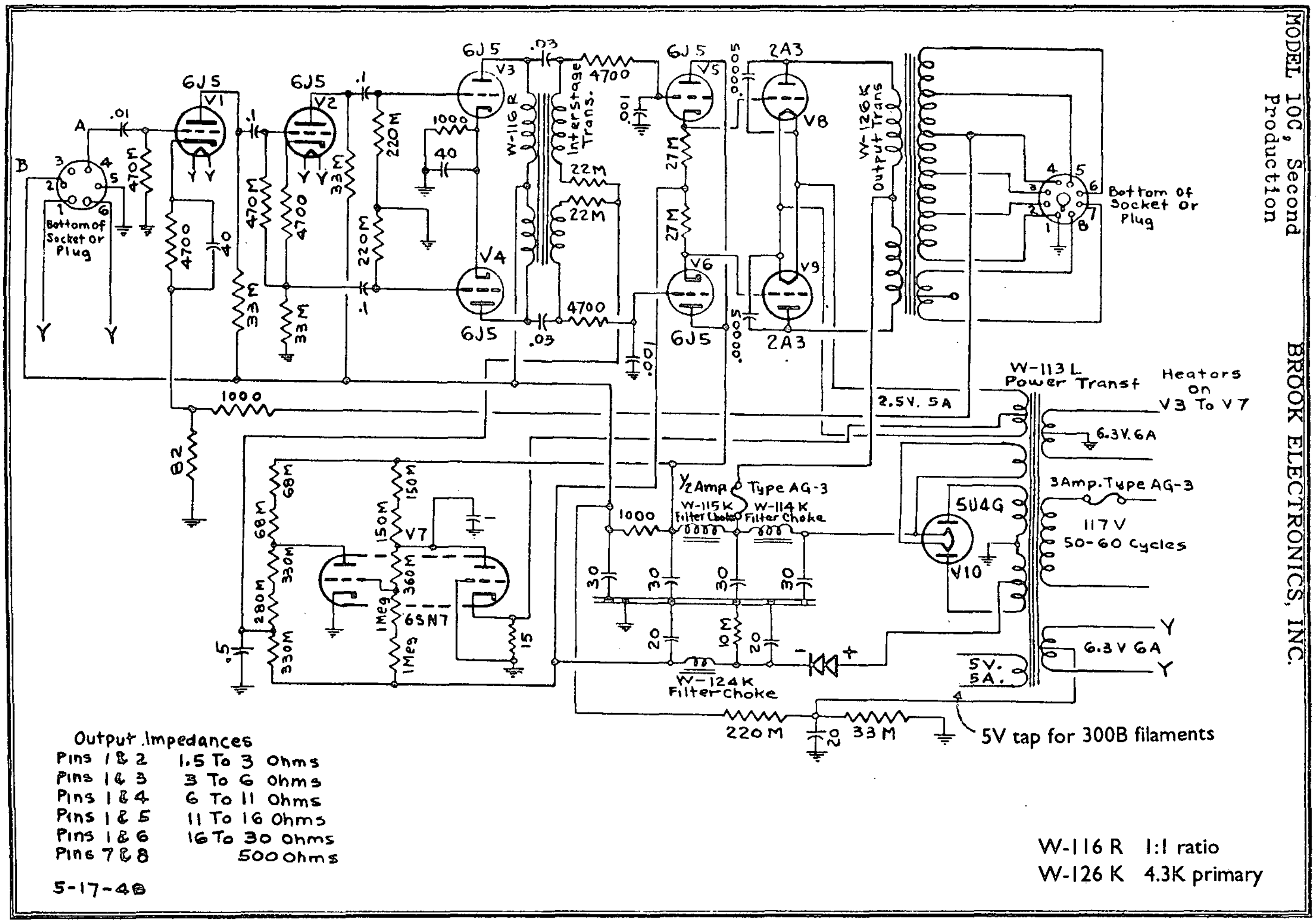
VOLTAGE READINGS

Item	Tube	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8
V 1	6SN7GT	35VDC	310VDC	85VDC	0V.	200VDC	9VDC	6.3VAC	0V.
V 2	6J5	0V.	0V.	275VDC	0V.	0V.	0V.	6.3VAC	10VDC
V 3	6J5	0V.	0V.	275VDC	0V.	0V.	0V.	6.3VAC	10VDC
V 4	2A3	#1.2VAC	330VDC	-67VDC	#1.2VAC				
V 5	2A3	#1.2VAC	330VDC	-67VDC	#1.2VAC				
V 6	5U4G	0V.	340VDC	0V.	370VAC	0V.	370VAC	0V.	340VDC

2.5VAC MEASURED ACROSS FILAMENTS.

BROOK MODEL 12A

Many who have heard them both maintain that the 12A is better sounding than its big brother, the 10C. A factory mod was available to optimize the Klipschhorn/12A3 combo - known as the 12A3-K1. Perhaps one of you Hi-Fi pioneers remember what it involved?



TYPICAL DISTORTION ANALYSES

POWER OUTPUT	MODEL 12A 10-WATT 2 WATTS	5 WATTS	10 WATTS	MODEL 10C 30-WATT 2 WATTS	10 WATTS	20 WATTS	30 WATTS
†INTERMODULATION (%)	.67	1.40	2.56	.97	1.24	1.22	1.69
HARMONIC DISTORTION (%)							
2nd	.08	.05	.12	.025	.24	.39	.55
3rd	.03	.24	1.10	.14	.23	.80	.30
4th	*	.025	.09	.005	.005	.05	.06
5th	.005	.03	.40	.03	.04	.39	1.10
6th	*	*	.07	*	.01	.02	.01
7th	*	.005	.21	*	.02	.04	.19
8th	*	*	.05	*	*	.005	.06
9th	*	*	.11	*	.005	.08	.25
10th	*	*	.04	*	*	.005	*
Total (RMS)	.086	.25	1.21	.15	.34	.98	1.30

† Intermodulation tests made with 60-cycle and 7000-cycle tones on 30-watt amplifier, and with 100-cycle and 7000-cycle tones on 10-watt amplifier, the 7000-cycle tone measuring 12 db below the low frequencies. The intermodulation percentage figures represent the ratio to the 7000-cycle tone of the rms sum of all intermodulation products. Measurements made with Hewlitt-Packard Wave Analyzer Model 300-A.
* Not measurable — less than .005%.

SPECIFICATIONS

	10-WATT POWER AMPLIFIER MODEL 12A	30-WATT POWER AMPLIFIER MODEL 10C
FREQUENCY RANGE:	20 to 30,000 cycles within 0.5 db	20 to 30,000 cycles within 0.2 db
POWER OUTPUT:	10 watts	30 watts
OUTPUT IMPEDANCES:	2, 4, 8, 16-ohms grounded and 500-ohms ungrounded	2, 4, 8, 16 ohms grounded and 500 ohms ungrounded
POWER CONSUMPTION:	110 watts at 117 volts, 50-60 cycles AC	125 watts at 117 volts, 50-60 cycles AC
GAIN:	55 db flat	55 db flat
INPUT IMPEDANCE:	500,000 ohms	500,000 ohms
TUBES (all triodes)	2-2A3, 1-6SN7, 2-6J5, 1-5U4G	2-2A3 (or 300B) 1-6SN7, 6-6J5, 1-5U4G
DIMENSIONS:	17" x 6¾" x 8½" high	17" x 8" x 8½" high
NET WEIGHT:	18 lbs.	34 lbs.
HUM LEVEL: ·	More than 75 db below full output	More than 75 db below full output
POWER AVAILABLE FOR TUNER:		90 MA DC at 280V DC; 4A at 6.3V AC

DAMPING FACTOR

Applies to both 12A and 10C

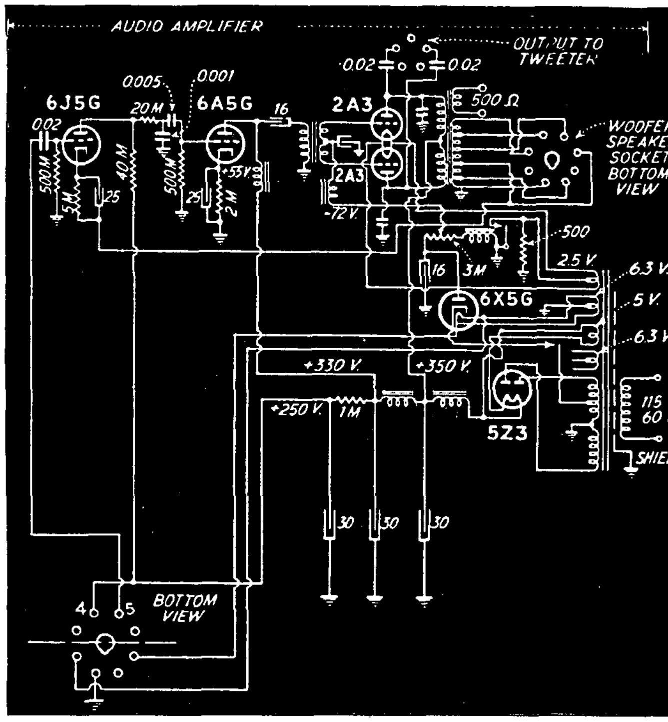
The output impedance on the 8-ohm tap is .8 ohms, giving a damping factor of 10. The other speaker taps have about the same damping factor.

The 500-ohm line has an output impedance of approx. 90 ohms, giving a damping factor of approx. 5.5.

TRANSIENT PEAK CIRCUIT

This Brook circuit development enables the 12A series of amplifiers to handle power peaks considerably higher than their ten-watt rating, at the same time holding distortion within the values shown above. This ability to handle peak transients for about half a second without increased distortion is a major factor in making the 12A amplifier a cleaner and more useful amplifier than its ten-watt rating would indicate

The automatic-bias-control (ABC) circuit used in the 30-watt Brook Amplifier more than doubles the power output and efficiency of the output system, at the same time greatly reduces harmonic distortion. The circuit automatically holds the plate current at small signal very rigidly to normal value, but permits the plate current to rise to the large values needed at high power output. The amplifier operates in Class A up to about 5 watts, and then there is a smooth transition to Class AB_2 operation at maximum power of 30 watts.



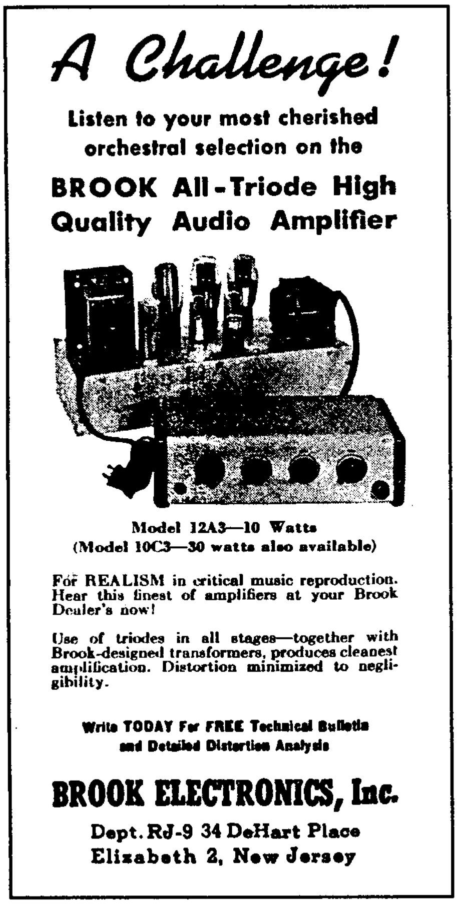
The grandfather of the Brook Amps: This is the audio amp of a "high quality" radio receiving system designed by Lincoln Walsh which appeared in *ELECTRONICS,* July 1939. Because of the low impedance driver stage, the fixed bias Class A prime circuit is claimed to deliver 30 watts peak at low distortion.

← The "natural harmonics" argument for triodes was probably already showing its age by the time the Brooks came along

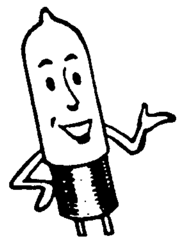
BROOK AMPS (continued from p.18) to give the listener the smoothest, most NATURAL sound reproduction possible. The problem of "listening fatigue, a disturbing by-product of many audio amplifiers, is eliminated as the triode circuit gives far less distortion of the higher order harmonics." Brook amps, according to the author of the 1947 article noted above, are free of the "strong desire to stop listening" which the high order harmonic distortion of pentode and beam tube feedback amps induce.

It should be noted that the 10C provided extra filament taps so that the amp could be connected for 300B outputs! The Fairchild 620 recording amplifier, an OEM version of the 10C with regulated B+ on the input and driver stages, allowed for use of not only 2A3 and 300B but also 6B4G outputs -- 3 different filament voltages! (see Read, Oliver, *Recording and Reproduction of Sound*, Sams, 1952, p.621).

The 10 C was intended for use in broadcast and recording applications,. PA systems as well as in "homes where the finest music and voice reproduction is desired." You could do worse even today.

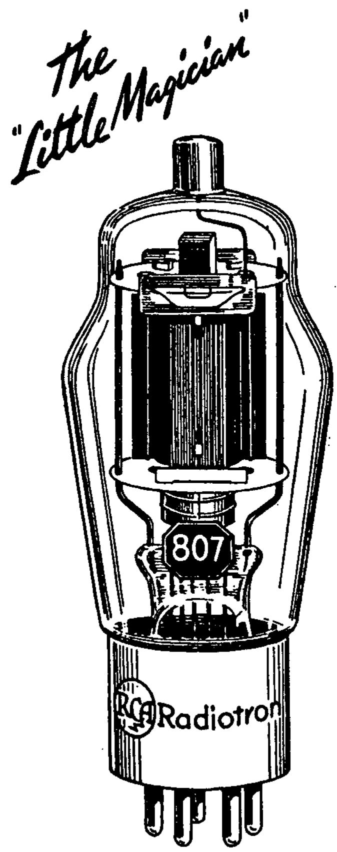


Brook ad from October 1949



Meet the Tube . . .
THE TRUSTY 807

The 807 came along at just the right time. Shortly after its introduction in 1936, it was catapulted into celebrity by the tides of world history. World War II swiftly created a huge demand for a rugged, stable, efficient, low cost, and versatile tube for communications uses. The 807 was as close to a perfect solution to that set of challenges as we have ever known.



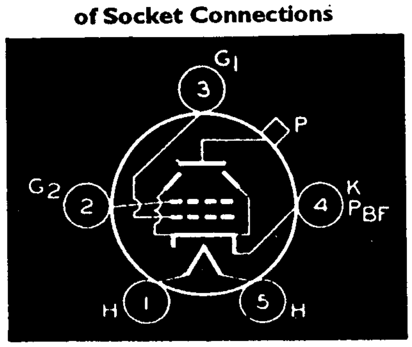
It was a tube for many purposes. The 807 was rated for Class A, AB1, AB2, & B audio service and Class B and C RF amplifier service. Its mastery of many disguises earned the 807 the title "The Little Magician" in the 1941 *RCA Guide for Transmitting Tubes.*

Luckily for succeeding generations of radio hams and audio experimenters, the 807 and its 12.6V, 7 pin brother, the 1625/VT-136 , were produced in such quantities during the war that the availability of cheap NOS surplus samples would be ensured well into the 21st Century. Some military transmitters used them for both modulator and RF power amp stages because it was easy to drive, not overly prone to spurious oscillation, and highly efficient. It is usually provided with a brown Micanol low-loss base but ceramic based units also exist.

Although they were used in many medium-priced PA amplifiers and in Altec and Westrex commercial gear, the 807 was never as popular in home Hi-Fi gear as other beam tubes like the 6L6, 5881, KT66, and 1614. Perhaps the exposed B+ on the plate cap argued against its use in the living room. It was specified in American versions of the British Williamson design in lieu of the KT66 and it was featured triode connected in some early Heathkit and Grommes Williamson-type amps.

With the dwindling supply and rising prices of primo beefy beam output tubes nowdays, perhaps the 807 is due for a revival. Just keep cats and children away from those plate caps!

Bottom View of Socket Connections



Tube Mounting Position
VERTICAL or HORIZONTAL

EQUIVALENTS

807W	Ruggedized Version
5933	" "
RK39	Raytheon
HY61	Hytron
350A	Western Electric
T-21	Taylor
VT-100	Military VT number

807

BEAM POWER TUBE

Useful at Frequencies up to 125 Mc

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:

Voltage	6.3 ± 0.6	ac or dc volts
Current	0.9	amp
Transconductance (Approx.) for plate volts = 250, grid-No.2 volts = 250, grid-No.1 volts = -14	6000	μmhos
Mu-Factor, Grid No.2 to Grid No.1 for plate volts = 250, grid-No.2 volts = 250, and grid-No.1 volts = -20	8	

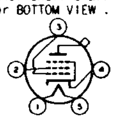
Direct Interelectrode Capacitances:

Grid No.1 to plate°	0.2 max.	μμf
Grid No.1 to cathode & grid No.3, grid No.2, and heater	12	μμf
Plate to cathode & grid No.3, grid No.2, and heater	7	μμf

Mechanical:

Mounting Position	Any
Maximum Overall Length	5-3/4"
Seated Length	4-31/32" ± 5/32"
Maximum Diameter	2-1/16"
Weight (Approx.)	3 oz
Bulb	ST-16
Cap	Small (JETEC No.C1-1)
Base	Medium-Micanol-Shell Small 5-Pin (JETEC No.A5-11)
Basing Designation for BOTTOM VIEW	5AW

Pin 1 - Heater
Pin 2 - Grid No.2
Pin 3 - Grid No.1



Pin 4 - Cathode, Grid No.3
Pin 5 - Heater
Cap - Plate

AF POWER AMPLIFIER & MODULATOR - Class AB1

Triode Connection--Grid No.2 Connected to Plate

Maximum Ratings, *Absolute Values:*

	CCS°	ICAS°°	
DC PLATE VOLTAGE	400 max.	400 max.	volts
MAX.-SIGNAL DC PLATE CURRENT*	125 max.	125 max.	ma
MAX.-SIGNAL DC PLATE PLUS GRID-No.2 INPUT*	50 max.	50 max.	watts
PLATE DISSIPATION PLUS GRID-No.2 INPUT*	25 max.	30 max.	watts

Typical Operation: *Values are for 2 tubes*

	CCS°			ICAS°°	
DC Plate Voltage	400	500	600	750	volts
DC Grid-No.2 Voltage**	300	300	300	300	volts
DC Grid-No.1 (Control-Grid) Voltage: *From fixed-bias source*	-28	-30	-32	-35	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	80	86	90	96	volts
Zero-Signal DC Plate Current	72	60	48	30	ma
Max.-Signal DC Plate Current	240	240	200	240	ma
Zero-Signal DC Grid-No.2 Current	2	0.9	0.7	0.5	ma
Max.-Signal DC Grid-No.2 Current	20	20	18	20	ma
Effective Load Resistance (Plate to plate)	3700	4600	6900	7300	ohms
Max.-Signal Driving Power (Approx.)°°	0.2	0.2	0.1	0.2	watt
Max.-Signal Power Output (Approx.)▲	55	75	80	120	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No.1-Circuit Resistance:°°

With fixed bias	30000 max. ohms
With cathode bias	Not recommended

AF POWER AMPLIFIER & MODULATOR - Class AB1

Maximum Ratings, *Absolute Values:*

	CCS°	ICAS°°	
DC PLATE VOLTAGE	600 max.	750 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	300 max.	300 max.	volts
MAX.-SIGNAL DC PLATE CURRENT*	120 max.	120 max.	ma
MAX.-SIGNAL DC PLATE INPUT*	60 max.	90 max.	watts
MAX.-SIGNAL GRID-No.2 INPUT*	3.5 max.	3.5 max.	watts
PLATE DISSIPATION*	25 max.	30 max.	watts
PEAK HEATER-CATHODE VOLTAGE: Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts

Typical Operation: *Values are for 2 tubes*

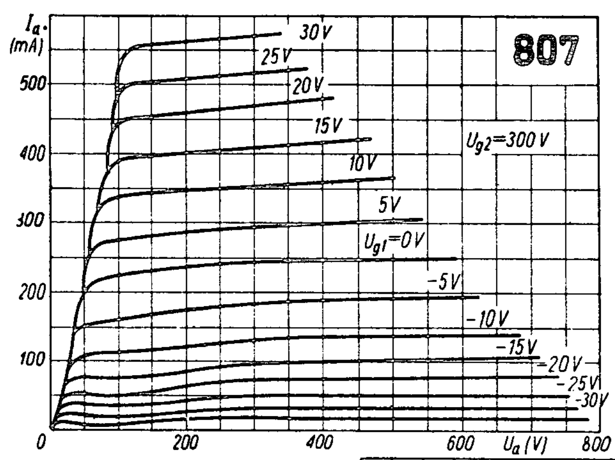
	CCS°			ICAS°°	
DC Plate Voltage	400	500	600	750	volts
DC Grid-No.2 Voltage**	300	300	300	300	volts
DC Grid-No.1 (Control-Grid) Voltage: *From fixed-bias source*	-30	-32	-34	-35	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	60	64	68	70	volts
Zero-Signal DC Plate Current	56	44	36	30	ma
Max.-Signal DC Plate Current	143	141	139	139	ma
Zero-Signal DC Grid-No.2 Current	2	1	0.6	0.5	ma
Max.-Signal DC Grid-No.2 Current	16	15	15	16	ma
Effective Load Resistance (Plate to plate)	6800	8200	10000	12000	ohms
Max.-Signal Driving Power (Approx.)	0	0	0	0*	watts
Max.-Signal Power Output (Approx.)	36	46	56	72	watts

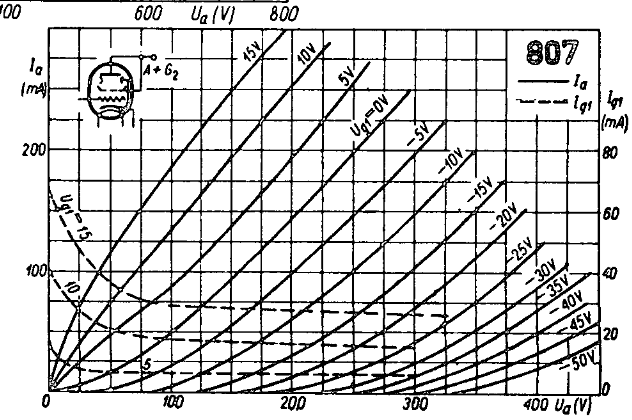
Maximum Circuit Values (CCS or ICAS):

Grid-No.1-Circuit Resistance:°°

With fixed bias	0.1 max. megohm
With cathode bias	Not recommended

An 807 based Williamson Amplifier - Summer 1952





Curves for 807 triode connected

The Core Issues:

Understanding Output Transformers Part 1 of a series

by Michael S. LaFevre, MagneQuest

"The Core Issues" will examine the function, construction, design, and operation of magnetics for audio applications. This series will combine practical advice in the form of useful "rules of thumb" with enough pure theory to give us some concept of how these magnificent devices work. This column is not an academic engineering tutorial but rather a guide to becoming an informed consumer.

In all of the audiophile kingdom, there is nothing more shrouded in mystery than the design and operation of output transformers. Many otherwise competent designers and audiophiles relegate the transformer art to the domain of "black magic." Over the next few installments of "The Core Issues", I plan to explore how outputs work and how these devices can be best utilized. Using plain language and practical examples wherever possible, I hope to shed some light on the mysterious goings on deep inside your transformer can. Hopefully, I'll be fortunate enough to successfully debunk a few myths along the way.

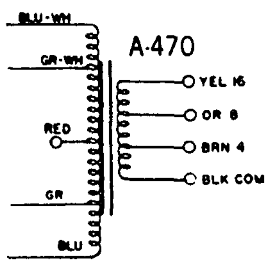
ASSUME AN IDEAL TRANSFORMER

As we did in our installment on power transformers in *Sound Practices* #1, lets begin our journey on the conceptual and ideal plane. An ideal output transformer would have no losses of any kind, it would have an infinite amount of primary inductance, it would have no leakage inductance and no capacitances of any kind. Its bandwidth (frequency response) would be as wide as any incoming signal and it would not cause any phase shifts or other anomalies which hamper the performance of real world transformers. An ideal transformer would be one that simply and perfectly either steps up or steps down voltages and currents in accordance with Ohm's Law.

To illustrate the operation of output transformers, let's use an idealized version of the Dynaco Stereo 70 output transformer (A-470) as an example. In most applications the designer will first select a primary impedance that will provide the optimum "load" that the output tubes should work into. This question is itself a subject of great interest and debate among circuit designers but for purposes of illustration let's assume our example provides an acceptable value for the tube type employed and its particular operational parameters. Early on the designer will also specify the working power level of the transformer as well as the secondary impedances -"output taps"- that must be provided.

In the case of our idealized Stereo 70 transformer, the primary impedance is 4300 ohms and it has a secondary that will provide for termination to a 4, 8, or 16 ohm load. Its maximum operating level (when it was first designed) is 35 watts. Of course, the poor ST-70 transformer has often been pressed into service under far from 'ideal' conditions in the afterlife by designers of 50 watt amps... but let's not throw stones.

Ideal Dynaco A470 @ 35 Watts output



PRIMARY		SECONDARY
4300ohms	Impedance	16ohms
268.8	Impedance ratio	1
16.4	Turns/voltage ratio	1
387.9 V	AC signal volts	23.7 V
0.09 A	AC signal current	1.48 A

If we view outputs as pure *step up* or *step down* devices we can see that they are inherently simple ratio devices. What you do on one side of the transformer determines absolutely what happens on the other side of the transformer and can be described solely through Ohm's law. The ST-70's output trans is, as most output transformers are, a *step down* device. In this case we want to transform or change the primary windings' relatively high voltage/low current electrical energy into a lower voltage/higher current energy level necessary to drive a speaker voice coil.

Using Ohm's Law we can calculate the voltages and currents of the primary winding. The primary AC voltage (E1) can be worked out as follows:

$$E_1 = \sqrt{Z_1 \times W}$$

E_1 *primary voltage*
Z_1 *primary impedance*
W *output power level*

In our example, the primary AC voltage level works out to be 387.94 Volts RMS.

The AC signal current (I_1) can be derived through the following equation:

$$I_1 = E_1 / Z_1$$

The result being 0.09 A (or 90 milliamps). To double check, remember that the AC primary voltage multiplied by the primary AC current must equal the power level calculated above.

Let us next calculate the secondary voltage and current.

$$E_2 = (\sqrt{E_1^2 \times Z_2}) / Z_1$$

The secondary currents are calculated by:

$$I_2 = (I_1 \times E_1) / E_2$$

So the secondary voltages and currents of the ST-70 output are the following:

Impedance	Voltage	Current
4	11.8	2.96
8	16.7	2.09
16	23.7	1.48

Again, to double check multiply the secondary currents and voltages together and you should get the power level of the transformer or 35 Watts. From the information we have so far we can determine that the power level of the primary exactly equals the power level of the secondary. This illustrates the first real lesson of transformers of any type - ***Transformers Are Not Amplifiers***. A transformer cannot deliver more power than that which is impressed on its primary winding. Ideal models show the same amount of power on both the primary and secondary sides. In all real world designs, there will always be less power delivered to the secondary than is present in the primary winding because of iron and copper losses.

What our idealized ST-70 output does illustrate is that voltages and currents can be "transformed" or changed from primary to secondary. The voltage ratio of the full primary to the full secondary can be stated as 387.9433 : 23.6643 or, in a more handy reduced form, 16.4 : 1.

In an ideal transformer (of any type) *the turns ratio will be exactly the same as the voltage ratio.* Therefore, in our idealized ST-70 the output transformer will have 16.4 turns of magnet wire on the primary side for every one turn of wire on the secondary. If we properly terminate the secondary with a 16 ohm load, then for every volt impressed on the primary winding there will be just .06 volts on the secondary but at much higher current.

IMPEDANCE

So far we have been speaking of voltages and voltage transformation. Most audiophiles are much more accustomed to discussions that use the "impedance" language in discussing output transformers. It is very rare indeed that an output transformer is specified on a voltage basis although it would be perfectly legitimate to do so. This is because the impedance ratio (in our example 4300 ohms : 16 ohms) is nothing more than the voltage ratio (or, alternatively, the turns ratio) squared.

turns ratio = voltage ratio
impedance ratio = voltage ratio squared
impedance ratio = turns ratio squared

Conversely, we have the familiar formula relating turns ratio and impedance ratio:

$$N_1 / N_2 = \sqrt{Z_1 / Z_2}$$

N *number of turns*
Z *impedance*

Hence, the impedance ratio of our idealized output trans is 268.8 : 1. And if we load the secondary with 16 ohms we will reflect back onto the primary 4300 ohms. Listed below are the impedance and voltage ratios of the secondary windings for our idealized example.

Secondary	Impedance ratio	Turns ratio
4	1074.9 : 1	32.8 : 1
8	537.5 : 1	23.2 : 1
16	268.8 : 1	16.4 : 1

Note that you can always calculate the primary impedance by multiplying the load placed on the secondary by the appropriate impedance ratio. *In other words, the primary impedance is fully determined by the secondary load and the turns ratio.*

MISMATCHING

Suppose we put an 8 ohm load across the 16 ohm tap, then we will have a primary impedance of only 2150 ohms - half of 4300 ohms. By extension, if we put a 4 ohm load across the 16 ohm tap, the impedance reflected to the primary will be only 1075 ohms or just 1/4 the impedance at which the transformer was designed to operate.

In the world of our ideal transformer, changes in the operating impedance would have no adverse impact on the performance of the transformer since we have conveniently eliminated the possibility of real world limitations. May be damn nice but it's simply not very realistic.

Although transformers are "just" ratio devices, not every real world application will yield optimal results. For example, if we put an 8 ohm load across the full secondary (16 ohm tap) on our 35 watt ST-70 transformer the primary current would be 128 ma (@ 274.3 V) and the secondary current would be 2.09 A (@ 18.7 V). The current handling demand on both primary and secondary windings is increased by 30% by this seemingly innocent maneuver!

Most transformers are incapable of handling this increased current demand without measurable diminution in performance characteristics. As current rises, so do net resistance losses in the copper magnet wire. Increased voltage losses cause greater temperature rise within the transformer compromising its efficiency even further. In output transformers, such losses are collectively quantified as *insertion loss*, usually stated in decibels. Certain very conservatively designed transformers can readily cope with 30% increases in current flow but these are rare units indeed.

Once you realize this, you may find it curious that some high end manufacturers have suggested trying different taps and choosing the "one that sounds best". The cautious side of my personality views this suggestion in the same light as the suggestion of the EQ manufacturer who recommends that you slide the treble and balance controls to where they sound "best". How do you know what you're ending up with?

Say you put your JBL Metragons (a 16 ohm load) on your 4 ohm tap, presto, you've just quadrupled the nominal impedance of the primary. Doing this trick on our ST-70 would yield a primary impedance of 17,200 ohms! Let me assure you that on 99.9% of all transformers that I have seen the result of quadrupling the primary impedance by matching "down" while maintaining the same power level would spell total disaster.

The chief limitation on "matching up", e.g. putting an 8 ohm load on a 16 ohm tap, is core saturation. The higher the impedance, the more AC voltage required to obtain a given power level. Once you pass the "knee of the BH curve" gross core saturation quickly sets in. To prevent core saturation and serious magnetically induced harmonic distortion, one must derate the power level of the transformer substantially when matching up.

Hopefully, engineers who suggest trying different taps are familiar with the real world capabilities and limitations of the iron they're using and make this suggestion in full awareness of the specific qualities of their transformer. Just be forewarned that before you can do this with confidence you must 'know your transformer'.

Aside from the basic questions of losses and saturation, other aspects of transformer design are affected by mismatching. The LF cutoff of a transformer is largely determined by the inductance of the primary winding. The higher the primary impedance, the higher the inductance required for a given low end rolloff. The effective inductance may be affected by mismatching since inductance is roughly linear with the magnitude of AC voltage excitation of the iron. At a lower effective primary impedance the AC voltage drive required to achieve full output is reduced. This reduction will impact on the incremental permeability of the core so that at low listening levels the transformer will produce proportionately less inductance than it would if it is operated at its design centers. Also as you mismatch up, e.g. by putting a 16 ohm load on a 8 ohm lap, you raise the frequency where the lows roll off because the impedance goes up but the inductance does not increase in proportion. Specification of an appropriate transformer for a specific set of conditions is a subtle balancing act.

We will return to the subject of impedance matching and mismatching as we further explore topics such as inductance, flux density, winding resistance, and the like in future installments of "The Core Issues". The point of this intro to a series on output transformers is to show that transformers are ratio devices and the primary impedance is determined by the load which terminates the secondary. Let us also keep in mind that there are limitations on the range of impedances which this ratio devices can be called upon to transform. The caveats which apply to improper matching will be brought under more detailed scrutiny as the series unfolds.

My focus here is solely on the effects of mismatching on the performance of the transformer but mismatching also impacts on the performance of the circuit which feeds into the transformer. A look at few of the equations in Gordon Rankin's article elsewhere in this issue will show that the impedance presented to the output tube at the primary of the output transformer plays an important role in determining the gain of the output stage. Incidentally, the gain, frequency response, and stability of even your "front end" can be adversely impacted by impedance mismatches between the output stage and the primary of the output trans. If the impedance at the primary (load impedance of the output tube) is halved, the gain of the output stage will be decreased and full rated output impossible to attain. Load tolerance of amplifier circuits varies but it is wise to note that the transformer does not function in isolation from the rest of the circuit.

A good *readable* reference relevant to the concerns of the audiophile on the role of primary impedance and its relationship to circuit performance is Technical Monograph #90-9 "Output Impedance Matching" published by the Valve Amplification Company.[1]

I tend to be conservative in my statements (*in print anyway - Ed.*) because I often get to hear widely circulated misinformation about transformers. For example, one manufacturer published a book which had a statement which has (perhaps inadvertently) led many audiophiles to believe that they should put their speaker load across the entire secondary winding so that there would be no portion of the winding left "flapping in the breeze". The indirect assertion was that it is undesirable to have the winding from, say, 8 to 16 ohms go unused and that this in itself would lead to deteriorated performance. With most transformers, the attempted homestyle cure for this "flapping in the breeze" is far worse than the ill it seeks to remedy. *With proper design* regarding the relative positioning and overall arrangement of the secondary windings, unconnected windings will have no negative effect whatsoever on output transformer performance .

Being the little devil that he is, your editor upon review of an earlier draft of this installment of "The Core Issues" brought up that some transformer spec sheets explicitly state that their transformers *can* be operated at half or double their nominally rated design centers. In their 1958 catalog, Peerless Transformers stated that:

> These transformers (*referring to their 20-20 Plus Series*) can be operated between a wide range of impedances because of the numerically large quality factor; nominal power ratings of the transformers change since they are determined by signal voltages across the windings as well as currents through the windings. When *this series* of transformers is operated between impedances which are half the rated value, the power ratings can be doubled. On the opposite <u>extreme</u>, the power rating must be halved when the transformers are operated between impedances which are double the rated impedance. Under these conditions, the insertion losses are also *doubled* or *halved*; this should be considered in application planning.

Please note that this application note was intended to apply *only* for the 20-20 Plus series. The next-in-line 20-20 Series, for instance, does not have the numerically large quality factor of the 20-20 Plus Series and was not recommended for such applications. For the uninitiated, "Quality Factor" is the ratio of inductance to leakage inductance. In the case of the 20-20 Plus Series this was 100,000 meaning that there is 100,000 parts inductance for every single part of leakage inductance. A quality factor of 100,000 is an absolutely amazing stat. Frank McIntosh in his patent application for his unity-coupled transformer proudly stated that his design was notable for achieving a quality factor of 75,000. To put it in context, the calculated quality factor of our loyal friend, the original ST-70 transformer, would be only 20,313. Perhaps it would be best to employ the A-470, as the designers intended, where it performs well.

Note that Peerless recommended that transformers must be rerated when they are "ratioed". And Peerless clearly advised that increased insertion losses would result. The point was that their premium series of transformers were designed with an abundance of current capacity in their copper circuits, allowing some flexibility in the range of impedances they would efficiently match. This would be useful when employing unusual tube types in circuits where there was no direct applicability of one of the other units in the series. But this application strategy was never intended to be used in the manner or for the reasons which some of our contemporaries might suggest.

In summary, the best practical advice I can give at this stage of our inquiry is think through the changes that you are imposing on the circuit and the transformer if you mismatch. In other words, know thy transformer well (both its capabilities and limitations) and know how it interacts with the circuit it's being used in. Don't mismatch a transformer purposely to try to remedy a real or imagined "flaw" of the transformer. Instead, if your transformer does not offer the performance level that you require at its proper operating centers, buy a good quality new or used unit that will meet your requirements without having to resort to shaky remedies. My own experience has been that transformers function best when they are not called upon to be "multipurpose" (that is to say "multiratio") devices but instead are used at their individual optimum operating points. This is invariably the design center around which they were conceived and executed.

Till next time many happy tunes to all.

1- Available from VAC, PO Box 4609, Sarasota, FL 34320 for $3.

A Report from the First Vintage/Classic Audio Fair

Chicago-Wheeling, June 27, 1992

by Kris Wawer

How do you organize a successful vintage audio show? Have you tried all the 'How To' books in the local library? I'll bet you think you can do it yourself; hire a dozen gorgeous models, put ads in all the flashy audio magazines, rent a posh hotel and give the best suites to the exhibitors. All sophisticated people of honor and authority will participate. *Sure*. Zorba the Greek's fragile construction will look as solid as a Mac 275 in comparison.

I've travelled from Nashville to Elgin and from Detroit to Houston in a van loaded with dozens of collectible vintage guitars - displaying, buying, selling, and swapping them at the major guitar shows. I simply *love* these shows. Wonderful collections of guitars and those who collect them. They have an incredible atmosphere - devoted buffs in collecting heaven.

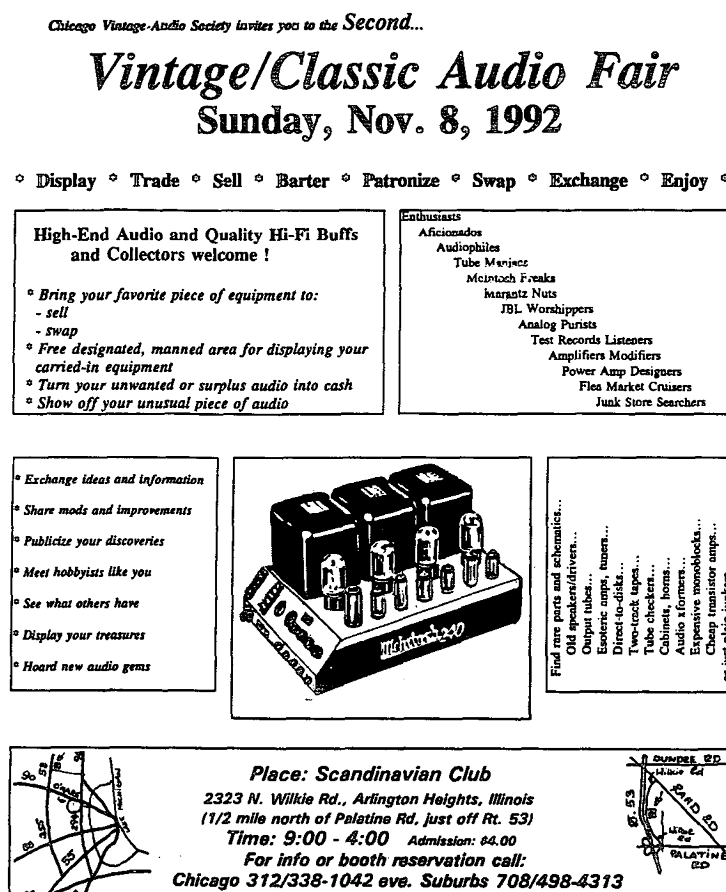
One day, I had the humble thought of organizing a vintage AUDIO show while driving to the spring guitar show in Detroit. I mentioned it to a collecting partner and he immediately suggested "Well, why don't you organize one?" I couldn't think of any quick excuse not to.

Several weeks earlier, I met a local fellow capable of inspiring conversation on a variety of topics in the wide world of audio. Mike Illfelder is well known in the local audiophile circles, he is pleasant and sociable, and he looks like me (which marks him as a very good looking guy indeed). HAH! The ideal co-organizer for the show. After two weeks of constant dialing, I knew his phone number so well, I could recite it at 3:30 AM after a night of jazz clubs and a barrel of single malt scotch. Alas, to no avail ... he was never, ever home.

Luckily, I had other recruits in mind. When the friendly brothers Mike and Dave Schultheis visited one evening, my directness surprised even myself: "Mike and Dave, you don't know it yet but I've decided to organize an audio show and you are in it with me. The decision is final and you cannot refuse! The group contains me, Mike Illfelder and the both of you." Well, I said more- actually, quite a bit more. But it worked! The idea proved infectious and immediately the ball started rolling. Mike Illfelder remained unavailable. We began to suspect he was on a secret CIA mission to a distant country or maybe even as far away as Peoria.

We needed a budget, most of which would be destined for advertising, and some sort of marketing campaign. For the promotional flyer, we needed a high recognition symbol as an eye-catcher. I chose the Mc Intosh 240 and it worked great! People would look at the Mac then scan the text. Often their faces lit up. It was inspiring to see people's reaction to the flyer. Popular reaction was predictable: *"It's about time!"*

Our plan was to recruit vendors from among our fellow audiophiles. Many had extensive, sellable collections of audio treasures. We figured that personal contacts and an ad in Audiomart would attract maybe ten hard core traders. Since there was little lead time before the proposed show date, we were prepared for the worst case scenario - only the three of us would be exhibiting. We decided to set admission at $1.00 so that people wouldn't bitch if we could not 'lure' enough exhibitors to justify a higher entrance fee.



Flyer for the SECOND Vintage/Classic Audio Fair uses the image of a powerful audio icon, the Mac 240, for maximum visual impact and crowd appeal

We needed more help in popularizing the show. Chicago is a *huge* metropolitan area. How do you reach the estimated 2000 audiophiles with a zeal for vintage audio? The budget was limited and the real choices were few. Flyer distribution through record stores, audio outlets, and similar places provided an inexpensive but time intensive medium which would reach the intended audience. Ed Stack offered to canvass the south and southwestern suburbs and distribute the flyer though his network of contacts. He signed on as an exhibitor and did an all around great job of getting the word out. Then Ron Steinberg joined our efforts and swiftly made good on his promise of attracting more exhibitors.

With the show four weeks away, I decided to launch a press campaign. I contacted Audiomart and got encouragement and support from Walt Bender. He had some experience organizing similar types of events on a larger scale and he warned me about some potential mistakes I could make. Walt was also very flexible on terms for payment. I was running low on cash, so Walt took some tubes on trade for the ad, saving my family from starvation. The ad in Audiomart had immediate results. Vendors beyond our local social network began to sign up. It looked like attendees would be getting good value for their one dollar admission after all.

Distributing the flyer to local hi-fi stores, I found that most owners/managers reacted positively. However some were uninterested, unwelcoming, or just plain jerks. One store owner in Chicago jumped on me vigorously, almost shouting and demanding the names and addresses of the people behind it. I goofily responded with all our names then voluntarily added phone numbers and shoe sizes. In the meantime his wife or daughter or whoever entered the arena and doubled his vocal efforts, raising the sound pressure level to about 99 dB. I felt that the stereo separation was excellent, however the left channel had intermodulation distortion caused by aging vocal cords (full identity and address of artist available upon request). I later determined that some store owners let me leave flyers on the counter then threw them away as soon as we left. Peace be with them, poor little people.

The phone rang continuously in response to our advertisements. Some real idiots called with the accusation that we were organizing a conspiracy to sell all our superior American audio goods to a particular rich nation. Yes, it is the truth. Because you are so well informed you force me to admit that we also organized the Second World War and promoted Woodstock Festival to demoralize our youth. Additionally, I am the person who invented Rock and Roll to sink this nation into sin and sexual hell! So be it!

As the big day approached, everything fell into place. Even the insurance company got into the act, quoting us a ridiculous rate to insure the show. We had a paranoid vision of some bozo dropping a power amp on this head and suing us for millions. Better safe than sorry. I put together a little bulletin with some notes, humor, and information on some of the exhibitors involved in the show. I was feeling good and very grateful and I expressed this by sugaring some people beyond the bounds of good taste in the newsletter. I even thought about launching the bulletin as a magazine with a potential worldwide readership of maybe 200 until I figured out that my family didn't have that many members.

The event was held on Saturday; on Friday night I felt that our job was over. We had more exhibitors than we could handle. People were coming from as far as Florida and Canada. I even got a few overseas inquiries but I discouraged them from coming early on in case the show was a flop.

As it turned out, we had about 20 official exhibition tables and more than 20 exhibitors; some shared tables with others. Major Chicago area collectors were present and their tables were full of eye-pleasing audio gear. Larry Dupon brought a small fraction of his collection of Mac and Marantz, probably the largest in the USA. Joe Waclaw presented a variety of tube amps and speakers at great prices. Carl Lindell brought a very rare set of Rogers-Eaton amps and some unusual English speakers. The Schultheis brothers presented a pair of excellent sounding speakers of their own design. Ed Stock and Harry Pallor had a table filled with the most desirable Western Electric tubes and high precision components. Steve Puntillo displayed one of the very first German reel-to-reel tape recorders and an incredible Kohl coherer from the beginning of the 20th century. There were Heil liquid-cooled speaker towers behind James Bond's table along with professional recording gear. Victor Paulis, formerly of Victor's Stereo, brought miles of interconnect cables and it seemed like he was giving them away. Arnold Shechtman had several very clean tube amps and Mike DeBroch presented a sizable display of current gear. Charles Crittendon had a variety of bargain-basement Electro-voice speakers and a collection of audiophile records. Fred Georges projected smiles across a display of Dyna equipment and Mick Johnson had some sophisticated modifications for Revox CD players, among other things.

There were more exhibitors than I mention here. Maybe I should have carried a notebook with me; I offer my lack of journalistic experience, constant administrative duties, and the general excitement of the day as excuses for any gaps in my report.

Many individuals walked in pieces for display and sale at the Community Table. The Community Table is a concept modelled on a common feature of guitar shows. We encouraged the general public to bring equipment to sell or trade and this attraction was an very important factor in the success of the event. Some collectors and exhibitors managed to snatch some very desirable pieces at excellent prices. The Community Table was constantly busy and was received with real enthusiasm by all participants.

The variety of equipment sold, traded and displayed would satisfy a wide spectrum of collectors and audiophiles. Even the most frugal ones could find excellent buys: single Heath W5Ms went for $40, integrated tube Sherwoods could be had for $25. I saw a mint ElectroVoice 15W changing hands for $40. That made me cry - I've got one and I've been looking for a mate for over a year! There were a couple of Mac 60s, sold by two different dealers at the price of about $400 each. A Mac 275 appeared on one table for a very short moment; the price must have been excellent, it rapidly and quietly vanished. A variety of EV and JBL drivers were available well below market prices and some of them were still available at the end of the day. The same fate met a pair of shinning Jadis 80; they attracted a lot of interest but nobody with enough cash to take them home for the price of a small car.

Some large, pro-looking reel-to-reels and plenty of professional studio equipment was available and sold after long negotiation. I noticed a pretty Micro-Seiki turntable changing exhibition tables and the same amplifier displayed first at one table and a little bit later in another corner of the room with a doubled price tag!

There were plenty of parts, tubes, and transformers and a couple of amazingly young fellows rummaging through them. They were seeking contacts with other amp builders and after I saw them with a group of guys chatting away energetically, I was sure they found who they were looking for!

The combined knowledge and experience of attendees was astonishing. Ron Steinberg invited Mr. Boom of Boom, Inc., a walking history of American professional sound installation. The scrapbook and photo album he proudly displayed was unique and fascinating. It brought to life the history of the Western Electric Company's era of dominance in the commercial sound market in the 30s and 40s.

The best deal of the show? A pair of massive, only slightly rusty American Projector basic power amps, studded with fantastic transformers for *FREE*! The worst deals? There weren't any.

I know that many people attended the show without paying admission; our policy was quite lenient and we really did not care. On the basis of a completely unscientific survey, I estimated that we had over 250 people in attendance. The actual number could be higher - the crowd at peak hours was enormous for the size of the room and it seemed a lot more than 250.

Some fellows spent the whole day hanging out at the show, talking their heads off and really enjoying themselves. The energy level was unbelievable. Almost everybody asked about the next show!

My partners were great PR agents and they executed the First Chicago Classic Audio Fair to everyone's delight and satisfaction. The show just happened the way it should. As Mike Schultheis summarized it on the day after the show: "It was the best vintage audio party that ever happened." The first show did cost us a little in the final accounting but it was worth every penny and all the man-hours dedicated to organizing it.
People loved it. We did too.

The Second Vintage Audio Fair is underway as we go to press. To get on the mailing list for future shows write to Kris Wawer at 1731 Elm St., Northbrook, IL 60062.
Hopefully, Kris' story will encourage you would-be audio impresarios to organize similar ground-breaking events in your area. Let us know if you decide to try.

Fixing Up Nice Old Radios
by Edward Romney
c.1990 Romney, Box 96,
Emlenton, PA 16773
No ISBN number

Ed Romney is best known as the name behind the "FIX YOUR OWN CAMERA" ads in the classified section of the bigger photography magazines. He publishes a whole series of books on the arcane and secret art of camera repair, loved by technically inclined camera buffs and cursed by "professionals"- probably as much for demystifying their black art as for any content issue. This is his first major publishing effort in electronics, the field in which he was formally trained while serving in the Army back around 1958.

This is not specifically a book on high fidelity audio. Romney starts at the beginning of electronics, going back to the first vacuum tubes and the birth of radio. He covers basic electrical and electronic theory before the transistor in a tour through the spark and crystal radio days, the first vacuum tubes, regenerative receivers, power supplies, RF amplification, and audio amplification. He then introduces superheterodyne receivers, multi grid tubes, communications receivers, old ham gear and "complex high quality radios and early hi-fi gear."

No need to ask which of these we are most interested in here, eh? The hi-fi section includes brief descriptions of early Williamson and Mc Intosh (pre MC 30) amplifiers. He touches on using Twenties radios as AM tuners as sources for hi-fi and other interesting tidbits. Also of interest are the audio sections of the Zenith Stratosphere, which uses eight 45 tubes in push pull configuration with separate woofers and tweeters fed from two different output transformers!

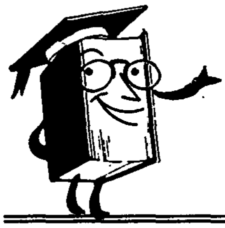
Romney's readable intro to tube electronics and collection of unusual circuits aside, the most interesting (or threatening, if you're an uptight liberal) thing about this book is Romney's running sociopolitical commentary. Basically, he's an old futz - one can infer that he's around 60 but his upbringing must have been strict 19th century - who rails out at the pernicious effect of "acid rock, violence, and sex" and the "ultra-liberal opinions of Dan Rather and Ted Koppel".

"The three networks are controlled," Romney reliably informs us, "by a New York elite that hates almost all that Middle America believes in...the American flag, marriage and family, law and order, and the Christian faith." If, like me, you grew up reading the American Opinion magazine-preferably with a Velvet Underground or Fugs tape running through a Twin Reverb in the background - this book will bring back memories.

So, you might ask, how good a book is this if you want to learn how to fix old radios? Not bad - as long as you understand that no book can teach you how to do *anything* - you'll have to experiment and learn to troubleshoot by doing. You CAN teach yourself - in fact, it beats paying good money to go to some bogus technical school staffed by retired Navy guys with nothing better to do - but you have to start simple. This is a good book as they go, but no one book covers everything. Get at least four or five good ones. Also keep in mind that repairing electronic stuff is different from building it and there are a lot of ace technicians who never built anything in their lives and couldn't if they wanted to.

If your only interest is hi-fi and you already have some tube theory down, I'd have to say that the $25 investment in this 180 page, GBC bound book might be best directed elsewhere. But if you need a readable introduction to vacuum tubes and some typical applications, have an interest in old radios, or, like myself, you just want to read some good old-time right wing bitching now and again, you should consider a purchase. See if you can get the local library to buy one: measured strictly on its merits as an "old radio book", it beats The Johnsons' "Guide to Old Radios" by a mile and Joe Carr's "Old Time Radios: Restoration and Repair" by at least the $10 price difference.

The Tubeskate



from the archives

Making Use of Load Lines

by Norman H. Crowhurst

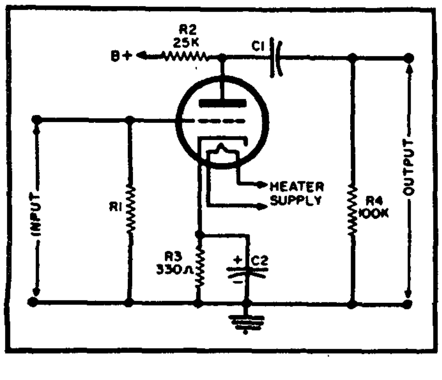
The gap between "theory" and "practice" can be bridged by using graphic tube characteristics and load lines.

Ever since the days when electronics went under the name of radio there has been a controversy between the "theory" and "practice" boys. The proponents of "theory" like to start by calculating a circuit in all its detail. After building it, they hand it over to a practical man to make it work. The practical man naturally argues that practice is of greater value because the theorists never arrange to arrive at the right answer the first time.

Often the designer who relies on theory does not take all of the factors into account. In "theory" a tube has simple characteristics which are listed in a neat little table and by using a convenient formula with algebraic symbols the gain of that tube in a certain circuit can be calculated. An amplifier designed on this basis often misses its objective in one of two ways: either it has less gain than was anticipated; or, if a margin of gain was allowed to take care of this contingency, it turns out to have considerably more gain than was required. It may also be deficient in that although it has the correct gain it will not handle the full output for which it was intended.

This sort of thing happens because the neat little table of tube characteristics

Fig. 1. A simple resistance-capitance coupled stage for voltage amplification.



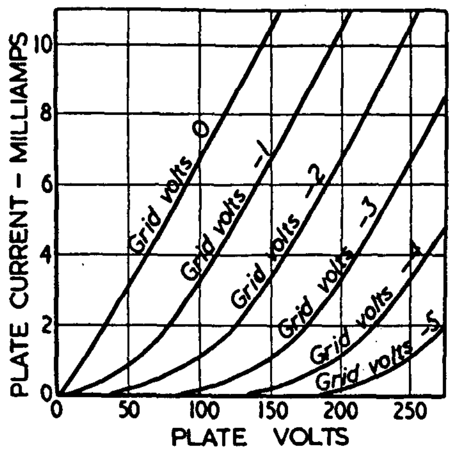


Fig. 2. Tube characteristics for use in the circuit of Fig. 1. Refer to article.

does not tell the whole story. The best link between theory and practice, which enables the prospective designer of an amplifier to come fairly close to the right answer the first time, is the use of graphic tube characteristics and the drawing of load lines. To illustrate this we will take a simple voltage amplification stage, the purpose of which is to receive a specified input voltage on the grid of a tube and amplify it as much as possible at the plate, in order to drive the next stage.

Assume that the circuit is the simple one shown in Fig. 1 and that the tube we have chosen has characteristics shown in Fig. 2. The first thing to do is to draw a load line (Fig. 3) from the "B+" voltage to be used across the tube characteristics at an angle representing the plate resistor R2.

This is done by taking the "B+" supply voltage of 250, in this case, and dividing it by the value of R2 (25,000 ohms). Thus, 250 volts divided by 25,000 ohms will give a plate current of 10 ma. The load line is then drawn between 250 volts and 10 ma.

Next we want to find what value cathode resistor (R3) is required to provide the right operating bias. This really is quite simple: we have to find a point along the load line that will be a suitable operating point to give the required degree of grid voltage swing without running into distortion and then find out what resistance in the cathode will give us the bias value corresponding to this operating point.

Suppose we know that the maximum voltage swing applied at the grid of this tube will be 1 volt, then from the tube characteristics, we will find that the best operating position is about 1 volt negative so that the swing of 1 volt alternately positive and negative from this position goes from zero to -2 volts. That this will give the minimum distortion can be seen by examining the spacing between the various curves representing different grid voltages. The spacing between the curves for zero, -1, and -2 grid volts is nearer equal along the line than any other pair of adjacent grid voltage curves. The spacing should be equal so that all of the waveform is amplified uniformly. To allow a slight margin to avoid the positive grid region which causes grid current flow, in case the voltage swings a little more than 1 volt, we will choose a bias voltage of -1.5 volts. This gives us the point B on the load line shown in Fig. 3.

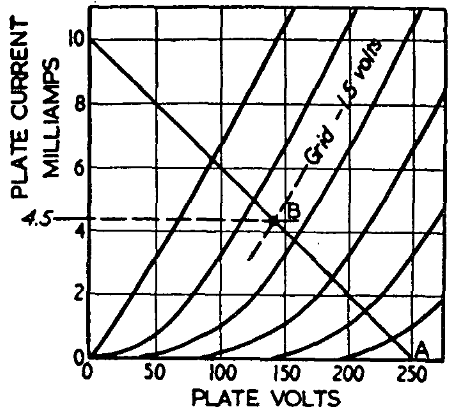


Fig. 3. First step in calculating values. The load line represents an R_2 of 25,000 ohms. The cathode bias resistor is calculated from plate current and the bias voltage operating at point B. Refer to text.

Referring to the current scale at the left-hand side of the tube characteristics, we find that point B represents a plate current of 4.5 milliamps. We now have the information necessary to calculate the value of the bias resistor R3; it must drop 1.5 volts with a plate current of 4.5 milliamps; this means its resistance value must be 1.5/.0045 = 330 ohms.

Now, to work out the rest of the circuit, in order to provide a voltage for driving the next stage grid, we need a coupling capacitor C1 and a grid resistor R4. To calculate the effect of these components on the amplification of the tube we have to recognize two things that may not be obvious at first sight: first, that the coupling capacitor C1 blocks any DC potential from the grid of the next stage and, second that at audio frequencies the reactance of capacitor C1 is negligible.

This means that, as far as audio frequencies are concerned, R2 and R4 are effectively connected in parallel because at one end the reactance of C1 has negligible effect, and at the other end "B+" is connected to ground through a low reactance decoupling or smoothing capacitor. So we have to draw another load line to represent R2 and R4 in parallel.

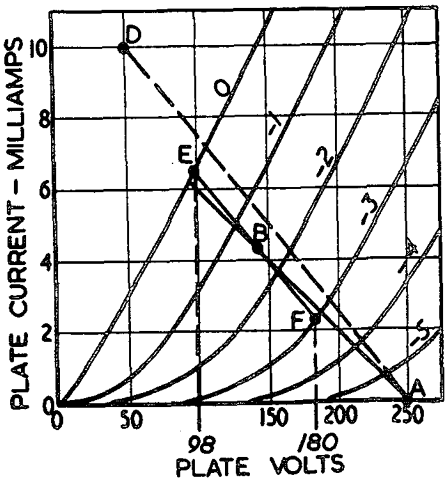
We can easily calculate the value of this load line from the formula R = (R2 + R4)/(R2 X R4). Assume for example that we choose 100,000 ohms as the value for R4. R2 has already been set at 25,000 ohms so the value of R works out to be 20,000 ohms

If R2 is actually 20,000 ohms instead of 25,000 ohms, the load line would be as shown dotted at line AD in Fig. 4. But because the DC feed to the plate of the tube is only through the 25,000 ohm resistor, the "direct current" load line is truly represented by the line AB, and the operating point has been set by choice of resistor R3 at point B. So the "dynamic load line", as it is called, or the load line for amplifying purposes is represented by drawing a line having the same slope as AD, but passing through point B. This is very simple to construct, by drawing a line parallel to AD through the point B. This line is shown as EF.

EF is shown connected between the grid voltage curves for zero and 3 volts, because the actual swing which will be employed for amplification purposes will not be greater than this -- actually a little less.

Now we can see how much amplification the stage will give. Point E on the zero grid voltage curve represents a plate voltage of about 98 volts. Point F, on the -3 grid voltage curve, represents a plate voltage of about 180 volts. So the grid voltage variation of three volts between zero and -3 will give a plate voltage variation of 82 volts -- from 98 to 180. These are convenient values to read on the graph but other voltages will run proportionally, so dividing one by the other, this means that a grid voltage swing of 1 volt will give a plate voltage swing of 82 divided by 3 = 27.3 volts. Otherwise expressed, this stage will show a gain of about 27.

Fig. 4. Remaining steps in calculating performance of stage. AB is the direct-current load line, obtained as shown in Fig. 3. EF is the dynamic load line, taking into account the effect of R_4 through C_1.



This method of working out the performance of a tube comes a lot nearer to the practical results than calculation using the algebra given in textbooks and the tabulated tube constants given in a tube manual. It will also show without any doubt whether the tube is capable of handling the volume level intended at the particular point in the amplifier without overloading, a point which use of the tabulated data in a tube manual may overlook.

All that is left in completing the stage is to determine the value of the cathode bypass capacitor C2. By good engineering standards the reactance of C2 at the lowest frequency to be amplified by the stage should be 10% or less of the cathode resistor R3. In this case, the reactance of C2 at, say 50 cycles, should be 33 ohms at most. This would work out as 100 mfd.

Pursuing the case we have just considered a little further, we know that full volume will represent 1 volt on the grid of this tube and that this 1 volt on the grid will produce about 27 volts on the plate. From there we can consider the next stage with the characteristics of a suitable tube, knowing that we will get up to 27 volts swing on its grid.

In this discussion, we have been working forward, i.e. we started with 1 volt input and worked our levels forward toward the output. In practice, it is often better to work backward from output to input. We know first what voltage we need at the grid of the output tubes. From there we work backwards to find what tube and what resistance values we can use to get this voltage to drive the output tubes. We then find what voltage this tube needs to swing its grid to give the required plate swing. Then we move back to an earlier stage to find how we can get enough gain from the available input voltage.

Irrespective of whether we work backwards or forwards, this discussion has shown how valuable a load line can be in determining a circuit for a simple tube. We have kept the discussion to a consideration of voltages, because the kind of stage we have talked about has been the one known as a *voltage amplifier.*

This article first appeared in the November 1955 issue of "Radio and Television News". Reprinted by permission of Gernsback Press. Readers' suggestions for future archives reprints are welcome.

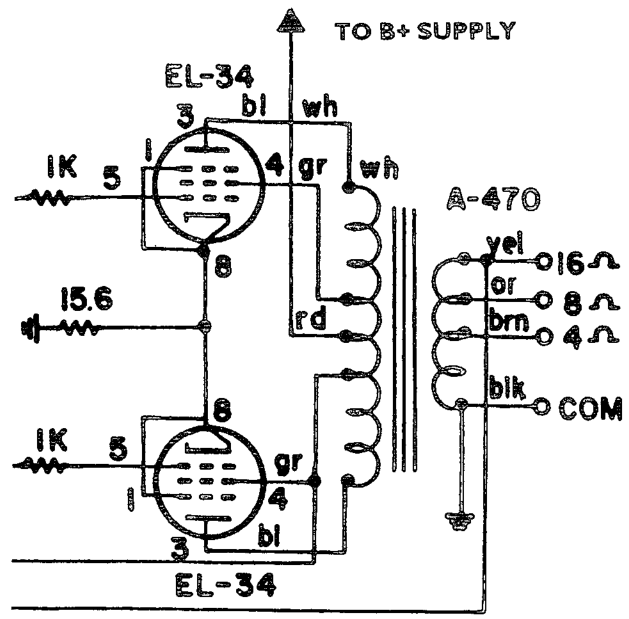
TRIODE CONNECTED PENTODES

HERB REICHERT, EDDY ELECTRIC INC.

Back in 1955, some of the big audio "issues" were: Which provides higher fidelity, triodes or pentodes? Feedback or no feedback? Active or passive? Solid core or stranded wire? Does this all sound familiar?

It was in this climate that D.T. Williamson's amp arrived. The old guard believed that there was no substitute for 2A3s push-pull. But the hot issue in the audio mags was high power. High power back then was only 20-30 watts, but it was thought that the extra headroom contributed to a sense of effortlessness. The Williamson amp tried to be both. Triode connected KT-66s gave this amp the low-distortion loadline of triodes with some of the gain and efficiency of beam power tubes. This circuit and its siblings became the most popular tube amps of all time. It also created the most popular tube modification of all time: triode connecting multigrid power output tubes.

It looks like we are at the threshold of a major triode revival and I suspect that the triode wiring of thousands of Dyna ST-70s assisted this trend. The first step for many towards pure triodes is to connect the screen grids to the plates of their present amp's output tubes and listen for a while...just to see what it sounds like and find out if there is enough power left to drive their present speakers. But. . . are we really listening to just a triode version of our present amp or some new hybrid?



For triode connection of this "typical EL-34 amp" disconnect both screen taps (gr) and connect plate (3) and screen (4) of each output tube through a 100 ohm resistor

When we connect the screen grid to the plate (usually with a 100 ohm, 1/2 watt resistor to suppress RFI) we really do get a new tube. A funny triode with a bunch of wires in the electron path. Some believe these leftover wires cause problems but we won't go into that here. This new tube has a more linear loadline, lower plate resistance, lower gain, and higher transconductance.

SPECIFICATION	PENTODE	TRIODE CONNECTED
Open loop gain	175 (44dB)	50 (34dB)
Closed loop gain	20 (26dB)	15.6 (23dB)
Feedback	18.8 dB	10 dB
Distortion (TH+IM)	1% @ 30 watts	2.7% @ 15 watts
Feedback factor (1-BM)	8.7	3.2
Sensitivity	1.3v for 30 watts	1.6v for 15 watts

TABLE 1:
EFFECT OF TRIODE CONNECTION OF TYPICAL EL34

This would be fine, but our present amp was not designed for this tube. Changing these characteristics of the output stage changes the electrical structure of the whole amp. These changes are significant and are more than likely what we hear when listening to our new amp. Let's look at some 'before and after' amp specs (Table 1).

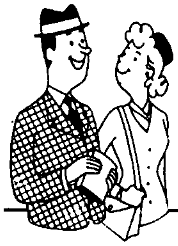
The numbers are approximate, but they illustrate exactly what is happening with a typical EL-34 amp. When we connect a tube in triode, we typically reduce the distortion of that stage by one-half. However, designers choose tubes primarily for their gain characteristics. In this case, the gain of the new tube is less than one tenth of the gain of the old tube. This changes the overall gain structure of the amp (see G. Rankin's article) and most importantly, it modifies the "gain reduction factor" due to feedback. Simply stated, feedback reduces distortion by a factor equal to the inverse of the gain reduction factor. Real simple? No?

Let me try again. When we switch to triode we reduce the gain and sensitivity of the amp causing us to use a bigger signal from our preamp. So why do many find happiness in triode connected pentodes? I suspect it's because a 10dB reduction in feedback makes the amp sound more "relaxed" and less bright. Feedback can thin out the sound, so this kind of reduction can give the new amp more fullness of presentation. Due to the above considerations, bandwidth and damping factor are reduced slightly, giving the amp a softer feel.

Output power is cut in half but many have noted that the apparent power in triode connected amps seems increased. This is because the amp now goes into and out of clipping more gracefully. Less sensitivity and less feedback allows us to drive these amps harder with less signs of distress. The more than doubled distortion shows up mostly as noise or lack of transparency. This can be corrected but would require a redesign of the amp.

Is it then a wise idea to convert? Yes and no. For many systems, the result of this change would be an increased enjoyment of recorded material and this is what we are looking for. It is certainly an easily reversible mod in any event. In a purist system, however, it would represent a compromise and the listener is advised to seek out a pure triode amp.

Perhaps there really is no substitute for 2A3s push-pull?



W.A.F.

by Joyce

FEAR OF FRYING:

Or How I Learned to Stop Worrying and Love My Home Audio System

Despite the fact that I've been married for years to an *audio geek extraordinaire*; despite the fact that back in college I owned the mini-component audio system that was the envy of the entire fourth floor of my dorm; despite the fact that I have artfully wielded a soldering iron (okay, so his arm *was* in a cast, and mine *was* twisted behind my back, no matter), I still find that nobody takes me seriously as an accomplished, dues paid-in-full, *audio aficionada.*

I really resent this. All I have to do is walk into a room full of "audiophiles" and the conversation goes something like this, "Yeah, this 6J5 output to primary voltage resistance is very *musical.* Oh, hi Joyce, bake anything interesting lately? Great. Like I was saying, try an unfilamented 90LX cap to ground next time and blah, blah..." Okay, so maybe electronics manuals *aren't* my favorite bedtime reading and maybe I *was* diagnosed with math anxiety at the tender age of eight. None of this means I don't like *music*, beautiful, tuneful MUSIC.

Furthermore, and this I believe is the clincher, *I KNOW HOW TO TURN ON MY HOME AUDIO SYSTEM!* Hey, no laughing! Seriously, we're talking *delicate* precision work, demanding *utmost* concentration and skill. Why, if it weren't for the prohibitive cost of the lawsuit that would surely follow, I'd even suggest, "go ahead and try it for yourself." Hah!

I will admit that it took some time to get the exact procedure down. Presently I have an advantage in that we've had the *same system* hooked up now for *3 weeks straight!* Amazing! Used to be I'd wake up in the morning, go into the living room and not recognize *one single* component. It was as if the Munchkins had switched everything overnight, plus they kept on digging deeper and deeper into the junker pile. But now, like I've said, I can pretty much tell what's what, and this is how it works:

The first step, after identifying your components, is to get the preamp going. This can be a little confusing, especially since our current system's preamp comes in *two* pieces and is *much bigger* than any amp I've ever seen. So I've devised this little jingle to remind me, "Two boxes, pre-amp; Four tubes, amp" which I can kind of repeat to myself as I go along. If I hit the right switch on the preamp (naturally none of the switches are labeled) a little yellow light starts flashing. Once the little yellow light *stops* flashing I know its time to get the amp (second part of the jingle) going.

This next part is very, very tricky. The homebrew amp we're using has *no controls* whatsoever, let alone an ON/OFF switch. What's more, I was recently given the following warning: "You see this thing here; it's our new amp. Don't ever, never, *never*, touch this bottom plate because its not grounded. And Honey, I know how clumsy you can be, so please don't move this amp when you're vacuuming, even if it is turned *off*, because I'm trying out different capacitors and this one here is just hangin' on by one little screw and these bad boys *really* store power, okay Hon?" *You bet!*

So, after always double-checking to make sure I'm wearing rubber soled shoes, my next step is to just plug the sucker in. A soft hum and the gentle tinkle of glass tubes warming up means I've managed to turn on the amp (step 2). A foghorn-like crescendo drives me to momentarily evacuate the room and try step 2 again as soon as I can force myself to reenter.

If all has gone well so far and those tubes start glowing merrily, I now proceed to select the next component. So what will it be: CD, record or tape? Well, since no CD player or disc, dead or alive, has ever made it into *this* house, and my own beloved tape recorder was long ago traded in for who only knows what, how about some good ol' vinyl? Analog forever! (I guess.)

Next comes the most challenging step. You see, the turntable hooked up today comes complete with its own *life support system.* Designed to float on a luxurious cushion of air, this marvel of modern audio engineering has its own personal oxygen pump (so noisy it had to be sequestered in the coat-closet) together with an immense coil of hospital-grade oxygen tubing. The tricky part is to ensure the turntable a constant, uninterrupted supply of pumped air, or else it will go into immediate audiocardiac arrest. After tenderly uncoiling 100 feet of oxygen tubing and checking for free passage of air, I am ready to flip the big switch.

Only one thing left to be done. Yes! The alligator clip holding the monstrous speaker cable to the absolutely gargantuan, singular speaker (its mate was too large to fit in the same room) is still in place! This aspect of turning on the system was a hard learned lesson; time and again I completed all steps toward the achievement of musical bliss only to be thwarted by such a small thing as a shorted alligator clip, resulting in a truly earsplitting whine. This time all goes well. I now give myself the all clear sign and, millimeter by millimeter, I gently lower the cartridge onto the spinning vinyl.

Now I ask you, *how could you possibly doubt my love of audio?*