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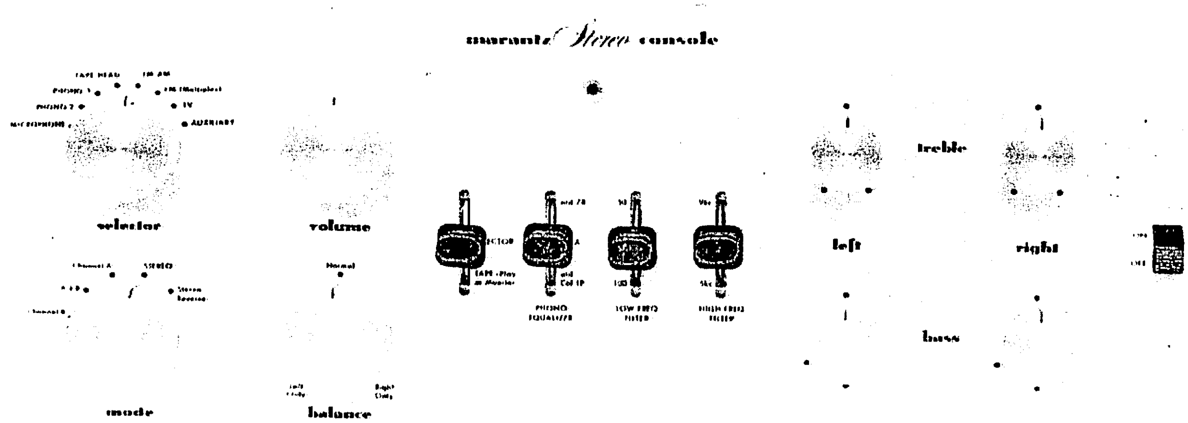
Audio Amateur

The pleasure of your company is requested at a radical parts transplant for the Marantz 7C Preamplifier.



Modifying the Marantz 7C *or* St. Pooge and The DRIAAGON

Part I: The DRIAAGON

by Walt Jung and Chuck Hollander

When the "RIAA-is all" debate was raging and some folks were claiming all preamps would sound alike if their RIAA circuits were calibrated within .1dB, we resolved to misdesign a scrupulously RIAA-accurate preamplifier, and use the worst possible components in it. Such a preamp, driven to crescendo, would exhibit TIM, SID, THD, and would audibly boom, ring, sizzle, spit, smear, blur, drift, constrict, compress, be opaque, and generally sound like the illegitimate offspring of a jukebox and a table radio. All this would be RIAA-accurate—proving that all preamps are *not* created equal!

But who would want such a thing? Besides, it would be too time consuming to build. We decided to find a pair of obsolete twenty-year-old preamps, with all the flaws of the period, to keep one as a control, and to rebuild its counterpart with right stuff. With the help of audiophile Ed McFeely, we got our hands on two Marantz 7C's, a classic of the tube era.

GAME PLAN

Our research design was to be as follows: the two preamps would be calibrated for RIAA accuracy, matched as closely as possible to each other, and to the RIAA curve. The basic circuitry, topology, feedback, amplifying devices, transformers, chassis, switches, jacks, pots, wires, solder, would be identical. To the experimental preamp, POOGE-1, we would perform the modifications suggested by Saul Marantz (*The Absolute Sound;* Vol II; no. 8, p. 425), which amount to replacing selected parts with newer ones of similar values.

In addition, we would replace *all* the signal-path capacitors following the rules set forth in Jung & Marsh's, "Picking Capacitors" (*Audio,* Feb & March, 1980). We would replace critical signal path resistors with 1% metal film types; and we would regulate the power supply following Boak's and Sulzer's suggestions (*TAA,* 1/80 and 2/80).

But that was it. We would *not* change any of the fundamental design characteristics of the device. We would retain the basic circuit, the six 12AX7 tubes; we would retain voltages as near as possible to the original values avoiding heat stress on related parts, value changes, and maintenance problems (some run the tubes hotter in recent 12AX7 designs). We would demur from isolating each tube with a filter capacitor following the dictum "the best capacitor is no capacitor," and also avoiding a technique that brings one to the "law of diminishing returns." We would gladly use the same amount of feedback even though the passive-RIAA advocates assert feedback distorts phase coherency, hence imaging. POOGE-1 would be an updating of the old Marantz by merely inserting select capacitors and resistors, and regulating the voltage.

TEST RESEARCH

At the time we had hopes for an A/B double-blind test. Several groups have been working on such things, collecting mountains of data, running computer routines on answers from elaborate questionnaires, only to get negative results (that no statistically significant sample can detect any differences between various preamps). We know of one such test where a listening panel compared an unmodified, but scrupulously calibrated Dyna PAT-4, to a Trevor Lees "Positive Vibrations" preamp with nearly all polypropylene capacitors. [*Audiophile Society Minutes,* Vol. 1, No. 6, May 1980.] They could hear no difference, following their carefully controlled test procedures.

Clearly, there is an immediately perceptible difference between a stock Dyna PAT-4 and the modified Trevor Lees; the PAT-4 is harsh while the latter isn't. From this and other similar experiences, we concluded the methodology for double-blind A/B testing has not yet been adequately worked out. Since the problems (switch boxes that may mask the sound vs. manual cable switching; short samples of music vs. longer samples) have not yet been solved—nor is there as yet a common vocabulary among audiophiles as there is among wine tasters or perfumers who also deal in subtle, but definitely real, differences—we are forced to use our own judgment as to the differences between the stock Marantz 7C and POOGE-1. Readers familiar with our work will have to judge for themselves and accept our idiosyncratic vocabulary. (See Rees & Shaffer, "Golden Ears vs. The Meter Reader," *TAA*, 4/79.)

We had intended to explore the notion that differences could be perceived in preamps exclusive of RIAA calibration; but since there was no "agreed upon scientifically valid" listening test, we wound up with no way to "prove" our assertions. We also wound up with a hell of a preamp. We decided to share our experience with those audiophiles who might still have an old Marantz 7C hanging around. The McIntosh C-22 preamp is so near a cousin to the Marantz that builders should have no trouble applying these same mods to that venerable device as well. (see ref. 14—bibliography.)

IN THE BEGINNING

Years ago, at some of the hi-fi shows, we were fortunate to have had personal conversations with Saul Marantz, and his one-time chief designer, Sid Smith. They said the Marantz 7C was designed for continuous maintenance-free operation. To achieve this many of its parts were over-designed; that is, they were purposely chosen larger than the demands of any current or voltage they

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would ever face. It turns out this is sound practice, particularly with regard to capacitors, for reducing distortion. Compared to similar preamps of the era, the Marantz ran cooler, at lower voltages, with less distortion, and was in the repair shop less often. Some 7Cs have been in service for twenty-plus years with only tubes and pots replaced.

To its credit the stock Marantz, even today has a characteristic sweetness on woodwinds and human voices. It presents a reasonable three dimensional facsimile of the recording's original environment achieved with a particularly clever variation on traditional feedback, called "open loop compensation," or feed-forward; and it has an abundance of dynamic range. So untouched, with all its ancient parts intact, it's not a "worst-case" preamp. A tribute to the 7C's sonic credibility is the price it still commands today; $595 in N.Y., $500 in L.A. (*High Fidelity*, Dec. 1980).

As good as it was, the Marantz was limited by the components then available; it used ceramic and paper capacitors, far from computer-grade electrolytics and carbon composition resistors, with only a few deposited carbon types in critical spots. Since zeners were neither plentiful nor cheap, its (half-wave) high voltage power supply was unregulated, and only lightly filtered. By today's standards, though it does have a certain nostalgic charm to its sound, the Marantz 7C has irritating sibilance and shrillness in the high end; the low end begins to roll off at about 70Hz in the stock model, with little "braking horsepower." This rolloff was designed-in to eliminate subsonics common to turntables of the day. Its imaging problems are considerable, and its symphonic string sections sound like one big violin instead of many ever-so-slightly differing ones.

□

A Quasi-Theoretical Discursus:

Resistors increase impedance. They are analogous to water spigots; they can be set to let nearly all the water through, or nearly none. They dissipate energy in the form of heat.

Carbon composition resistors, if you've ever cut one open, are made with a powdery, graphite-like substance in the middle of a hard plastic shell, with a metal cap on either end, and wire leads coming out of the caps. Sometimes the caps are inside the shell, so it seems the wire is coming out of the body directly. In such a situation there is a potential for "dioding," or high frequency distortion as the current passes back and forth. The current (or signal) may be subject to imperfect conduction between the resistor's cap and its wire lead, and between the cap and the graphite powder that is the resistive load itself, as well as among the grains of the graphite powder. The typical carbon composition resistor is 20-40dB noisier than the typical metal film resistor. This noise sounds like "harsh" or "hiss" and is of sufficient loudness to mask details at critical points, particularly high-frequency transients.

Furthermore, carbon composition resistors are heat sensitive, and while they may initially be accurate to ±10%, after repeated off/on surges with expansions and contractions due to heat, they may drift out of tolerance by as much as 20%. So, using such resistors in critical parts of a circuit, say the RIAA section, may in time lead to sonic inaccuracy.

Metal film resistors are manufactured using different materials and methods. They are accurate to 1% or better, with some wire-wounds accurate to .01%. Metal films are much less temperature sensitive, hence less liable to suffer failure or drift. Subjectively, they are noticeably less noisy, and being more accurate, they keep the tonal spectrum in balance.

SLOW FLOW

Capacitors fill up with electrons and discharge when called upon, something like inverting a bucket. But a bucket will empty at varying speeds depending on the viscosity of its contents. Water empties faster than molasses; polystyrene empties faster than ceramic; polypropylene empties faster than polyester. Some capacitors empty ten to hundreds of times slower than others, and while the last little bit of energy is dribbling out (like treacle from a bottle), the next transient appears. The residual signal, or afterimage, mixes with the newly arrived signal, and each transient has a tracer-bullet effect on a slow capacitor, each leaving afterimage in the signal. [For a more detailed technical description of this phenomenon, see Marsh's accounts of dielectric absorption problems in "Picking Capacitors" (*Audio*; March, 1980 and *TAA* 4/80, p. 31].

If 10 to 15 capacitors are in the signal path from phono-in to amp-out, these afterimages pile one atop the other, we get hash, and the inability to hear subtleties of lower amplitude than the level of the hash. Music sounds veiled, compressed, lacking inner detail; the bass is muddy. In general the sound is stripped of its vibrancy and lifelike character. Instead of goose-bumps, we get the blaahs.

Certain types of capacitors (higher K factor) seem to have longer afterimages; others' performance is frequency dependent, and still others' performance is amplitude dependent. Some do a "bad" job on the high frequencies (tantalum, aluminum, ceramic), while others (polyester) handle the highs somewhat better, only to introduce bass ringing. Bad bass is subjectively described as "wooly, flabby, tubby, uncontrolled, and lacking authority."

What does that mean? On Linda Ronstadt's album, *Hasten Down the Wind* the bass guitar on the song "Crazy" presents a good test. If the bass rings, the notes go BOOOOM BOOOM with little elapsed time between. Correctly, they should go BOom...BOom...with greater apparent time lapses. A good preamp seems to have more "braking horsepower;" the notes are described as "controlled, tight, accurate, clean, textured." We mean there is no afterimage; the note doesn't linger while all the afterimages from each of the many capacitors in the signal path catch up.

AFTERIMAGE SPIT

Capacitors can introduce bass-ringing in a signal; and though this error may be only milliseconds in duration, it muddles other low (and mid) frequency information that's trying to get through. Subjectively, ringing bass makes low frequency information seem bigger, or warmer. This type of error is often perceived as a plus by those who like their bass BIG, their music "lush and romantic." The notes themselves are not louder, there is no shift in the sound spectrum, rather each note lasts toooooooo looong. The error is not one of RIAA calibration, but one of bass transient duration. Such preamps measure on the bench with sine waves as RIAA accurate, and have no unwanted peaks, but they nevertheless color the sound; they add "warmth." They sound as if they have a peak in the mid-bass (150-300Hz), and have muddy deep bass. They are wrong.

Similarly, 5k–10kHz hash—something like tape hiss in steady state—and like offensive crackling cellophane on high frequency transients, such as vigorous violin bowing, is frequently noted in preamps as "sizzle." This sizzle is often the effect of ceramic, tantalum, or aluminum (or all three) capacitors in the circuit. Many preamps using such capacitors look O.K. on the test bench, but sound "bright.'R It is, again, because certain types of capacitors have afterimages at certain higher frequencies, and at louder levels. "Tantalum capacitors will exhibit harmonic distortion as a function of signal amplitude." (Nelson Pass; *TAA*, 2/79, p. 55) Even though RIAA calibration is scrupulously correct, certain capacitors can introduce distortions that sound as if the preamp had a rising response curve. The error is one of excessive high frequency transient duration due to afterimage, and the resulting IM distortion; such preamps sound "bright" as if they have a peak in the high frequencies. They are wrong.

THE FLUSH FACTOR

Power supply regulation is another such phenomenon. It has no direct effect on the RIAA calibration. But by keeping the operating voltages right on the button, there is less likelihood of minute "voltage sags" that occur with transient peaks. These voltage sags, common to unregulated power supplies, exist for milliseconds in real time, but they are subjectively experienced as bass ringing, as mid-range transient blurring, as image shifting, as changes in timbre, and in extreme cases, as lateral image shrinking with increases in signal. How does this work?

Imagine a household in which one person is taking a shower, with the water adjusted for a mixture of hot and cold, and another person flushes the toilet. The pressure in the shower drops suddenly, and the temperature becomes scalding hot. Now imagine a device that keeps the pressure and the temperature in the entire system constant, no matter what else is done with the water in that household. The flush equals a large transient; the drop in pressure is analogous to the voltage sag; the change in temperature of the shower water is analogous to unwanted error or distortion (due to the sudden imbalance created by the transient, or flush); and the device that keeps the water pressure (hence temperature) constant, is the voltage regulator.

Good wide-band voltage regulation gives better braking horsepower on bass transients, avoids ringing and blurring; it stabilizes right/left and near/far imaging; and it keeps the soundstage from shrinking with increases in gain. Best of all, mid-range transients are much sharper and cleaner than with unregulated power supplies. On symphonic works, though the drums may crash and the trumpets bray, you can still pick out the relatively quiet bassoons brrrmmmppping away.

With all this in mind, we decided to replace the critical resistors of the POOGE-1 with 1% metal films (to reduce noise and improve overall accuracy), to replace the signal path capacitors according to the rules put forth in "Picking Capacitors" (to eliminate sizzle, crackle, and BOOOOM), and to build a power supply regulator (to eliminate mid-range blur and generally improve imaging). We expected these improvements to clean up the 7C and bring it "up to date." **End Quasi-Theoretical Discursus.**

□

RESULTS

After we replaced the necessary parts, POOGE-1 was a very solid, first-rate preamp. It may not have been quite top of the line, but it was not far behind. Gone was the ceramic shrillness and crackle. Gone was the tantalum sizzle and spit. The noise dropped dramatically. Gone was the high-frequency hiss. The bass went all the way down with chest-cavity-resonating urgency, yet had lots of stopping power. Bass-ringing disappeared. Transients became razor-sharp.

The veils were removed with each improvement until it seemed we could sense the recording engineer's hand on his controls; that is, not only were instruments crystal clear, but it was apparent when a touch of a 7kHz "sheen" had been added to a string section. String quartet members stayed in their respective chairs; that is, the right hand violin would not suddenly appear to the left as the music got louder (hear Borodin's *String Quartet in D;* Philips 802 814 LY). Nor would choir voices attempt to cluster blurringly in the center upon crescendo; they stayed put (hear Monteverdi's *Lamento d'Arianna;* Archiv 2533 146).

The POOGE-1 became so analytical it revealed badly mastered records as more than a little annoying (hear Bach's *Brandenburg Concertos;* Nonesuch HB-73006); but allowed well-mastered records to sound like master-tapes, or just plain wonderful (hear Prokofiev's *Romeo and Juliet*; Sheffield Lab-8). POOGE-1 is a stunningly life-like preamp. It now compares favorably with the best modern preamps.

SOURCE SAMENESS

Its father, the Marantz 7C, was forgiving and tended to make various records sound pleasantly similar. It also made various cartridges and FM tuners sound alike. In other words, through the old resistors, capacitors, and power supply, various signal sources sounded similar.

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This leads to another can of worms, one we'd rather shy away from, but one upon which we feel compelled to comment. What can we infer from a situation where one preamp makes all signal sources sound similar, while another makes them sound distinct? We infer one is functioning at a higher level, resolving subtler distinctions, while the other is masking them, tending to make everything sound the same.

Some hold that "all-amps-sound-alike-through-octave-equalizers." They are so filled with enthusiasm for their enterprise, they fail to ask some fundamental questions, like: "Are my results an artifact of my method?" That is, if I have two preamps, and one is twenty years old and sounds harsh, while the other is brand new and sounds great, but they sound alike through the octave equalizer, what is the equalizer doing to make otherwise different sounding preamps now sound the same? A reasonable enough question.

As far as we know, manufacturers of the octave equalizers so dearly cherished by some "RIAA is ALL" theorists, are still using some of the poorer quality components mentioned. To say all amps and preamps sound the same once they've been octave equalized, is to say (even unwittingly) that all equalizers introduce so much sizzle, hash, bass-ringing, afterimage, phase shift, and other execrable garbage to the signal as to make "top quality" and "worst-case-jukebox" gear sound the same. This sonic homogenization can be true of double-blind switch boxes as well, though to lesser extents and for different reasons. [See J. Curl (interview), *The Absolute Sound,* Vol. 5, #17, March 1980, p. 56-62. P. Moncrieff, "Do Amplifiers Really Sound Different," *IAR Hotline,* #1, Sept. 1980, p. 10-14.] The chain is only as strong as it weakest link, and listening tests using such contaminating links are obviously open to serious question.

COST FACTORS

The hidden agenda in this argument is dollar value. A lot of audiophiles feel (often rightly so) that a lot of charlatanry and chicanery is being foisted on the uninitiated in the name of audio guru wizardry. They believe one needn't pay thousands, or indeed tens of thousands of dollars to get high quality audio. As a result they make claims aimed at minimizing expense. "Any good 50 watts per channel receiver, through an octave equalizer, will sound as good as any super high quality amplifier. The only thing you get with higher cost is more headroom, more power reserve." It's as though their real motivation is to avoid being duped, to avoid overspending. In their zeal, we believe they err.

There are other considerations besides RIAA accuracy and headroom, as this article has hoped to illuminate. Some are related to cost. Metal film resistors cost many times more than carbon composition types; and polypropylene capacitors cost as much as three to five times as much as polyesters. A good power supply regulator obviously costs more than none. But if you have, or buy, an old Marantz 7C or a McIntosh C22 and you perform all these modifications yourself, the parts will cost you about another $100, tops. This preamp will not embarrass you when compared with anything now on the market at any price. Some may do certain specific things better, but overall, it is a good performer. □

PART II: THE MODIFICATION

THE COMPLETE ORIGINAL 7C schematic is reproduced here as *Fig. 1* (having previously appeared in *TAA* issue 4/74, p. 36). You may use it as a jumping off point for altering a 7C in more piecemeal fashion. Those stages seriously altered are redrawn below, in greater detail, with original reference designations of components in use, but with switching functions not shown.

Since we anticipate that readers may wish to reproduce these changes in various forms, the discussions are partitioned into phono changes, high level changes, and power supply changes; so that each may be of proper context for both the scratch builder and 7C modifier. The parts list and specifications for each section is the schematic, and the circuit discussions themselves which detail critical areas. Pay strict attention to the notes and qualified vendor information as the recommendations given have not been derived casually.

PHONO PREAMP

Figure 2 is the simplified revised phono section with all altered RIAA playback components specified. We did not change the microphone and tape playback functions in the POOGE-1, thus they are not shown.

As you can see, all signal path resistors (with no exceptions) are changed to 1% metal film units of the closest easily available IEC standard value. (*See photos 1A and 1B.*) In general this would imply the military RN60D's, and for R_{73}, an RN70D unit, because of the higher relative dissipation for this point. The original 7C design concept specified ample derating of all resistors and this idea is no less valid today. Today's components allow considerably more freedom of course; but among the better resistors available when the 7C was designed were deposited carbon types, which when employed at points of low level and/or large DC voltage drop (such as R_{65}), minimize noise generation. Their lower relative current noise, makes them superior to carbon composition units. For a given resistor value, a larger wattage rating will generally yield less noise (for a specific operating point).

The use of high quality resistor types for sonic improvement has strong precedent among audiophiles and considerable documentation in *TAA's* pages. The first of these was the editor writing on the PAT-4 in the premiere issue in 1970[5] and later D. Vorhis in his PAS articles[3,4] These claims were supported by readers Chase[27] and Dudley[23] and Saunders[22] The reactions generally are not limited to any specific type of topology; reader Randall[28] for example, found the increase in definition "dramatic" in a solid state preamp, after substituting resistor types.

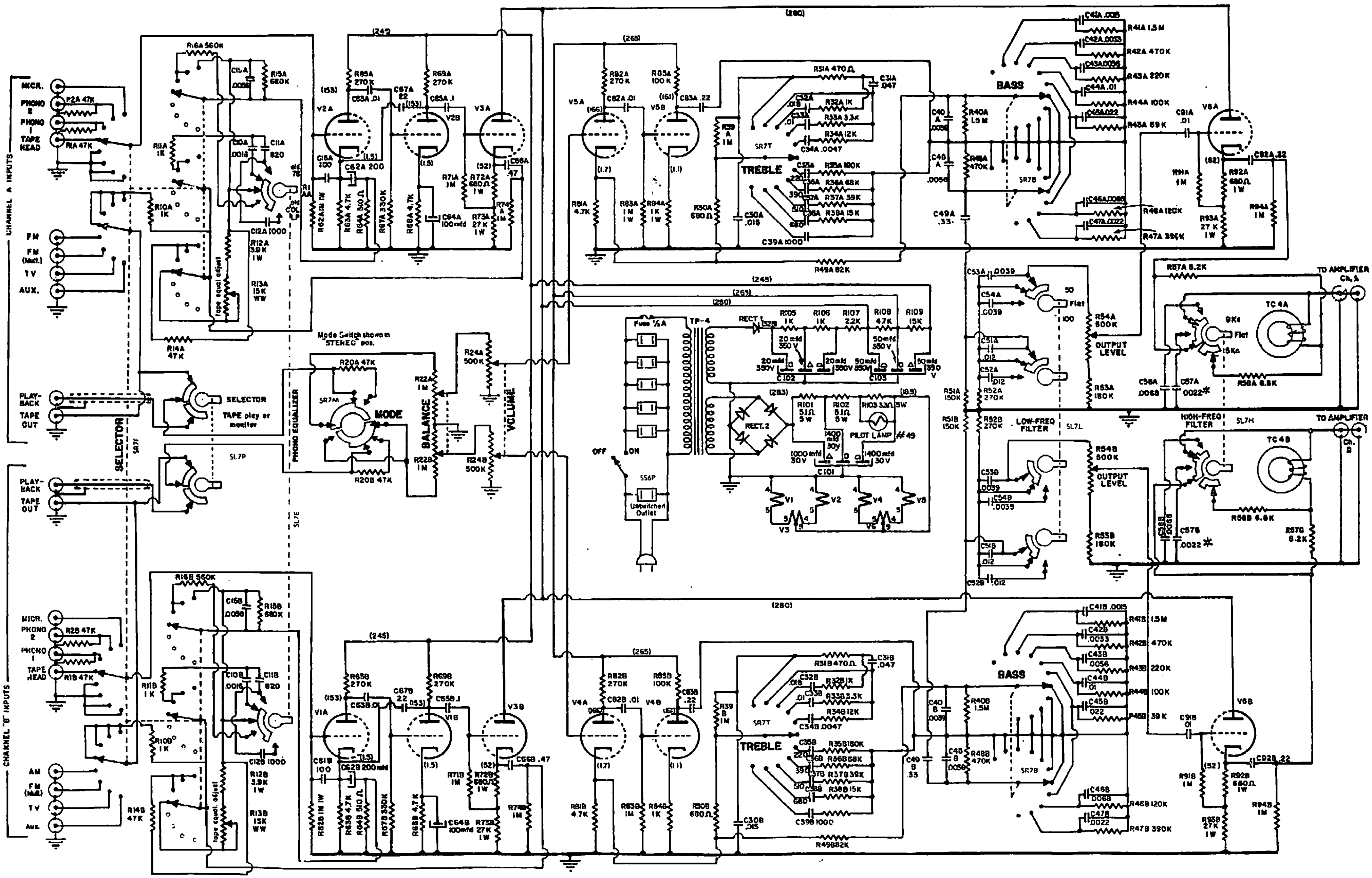
While it is beyond the scope of this article to go deeply into objective measurements, these problems have been discussed by John Curl[31] and by one of the authors[2] (see his *Figs. 9A and 9B*). The evidence apparent in these discussions certainly seems to be saying that resistors in themselves can influence the sound, independent of circuit topology. This has even been reported under blind AB listening conditions, by Kuby and Otala[36] where a volume control was a source of masking.

Therefore select both fixed and variable resistors for sound quality. Investigate control potentiometers contact problems, and even end caps on some fixed resistor types. In our experience only the highest quality metal film resistors should be used in the signal path, and for the circuits here we have had good experience with (and recommend only) the resistors by Corning Electronics in their RN55D, RN60D, etc.types (these were first recommended to WJ by Dave White, but appear to be well appreciated by audiophiles in general).

Any reader who has specific experience with such type comparisons is encouraged to share them via *TAA's Letters* column. Surplus metal films of mixed origin will no doubt outperform carbon composition or carbon film resistors; we do not imply this is not so. However, even among metal films, specific types are preferable.

The capacitors used in the preamp are generally film types; replacing the original model 7C's paper and ceramics. (See *Photos 2A* and *2B* as well as *Photo 3.*) Dave Vorhis[4] discussed how capacitor upgrades improved his PAS, specifically recommending polycarbonate types, (if available). Since his PAS articles appeared even better film capacitors have become more generally available, and

FIG. 1


CHANNEL A INPUTS
MICR.
PHONO 2
PHONO 1
TAPE HEAD
FM
FM (Mult.)
TV
AUX.
PLAY-BACK
TAPE OUT
SELECTOR
TAPE play or monitor
PHONO EQUALIZER
Mode Switch shown in "STEREO" pos.
MODE
BALANCE
VOLUME
tape equal. adjust
CHANNEL "B" INPUTS
AM
TREBLE
BASS
LOW-FREQ FILTER
HIGH-FREQ FILTER
OUTPUT LEVEL
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RECT. 2
TO AMPLIFIER Ch. A
TO AMPLIFIER Ch. B

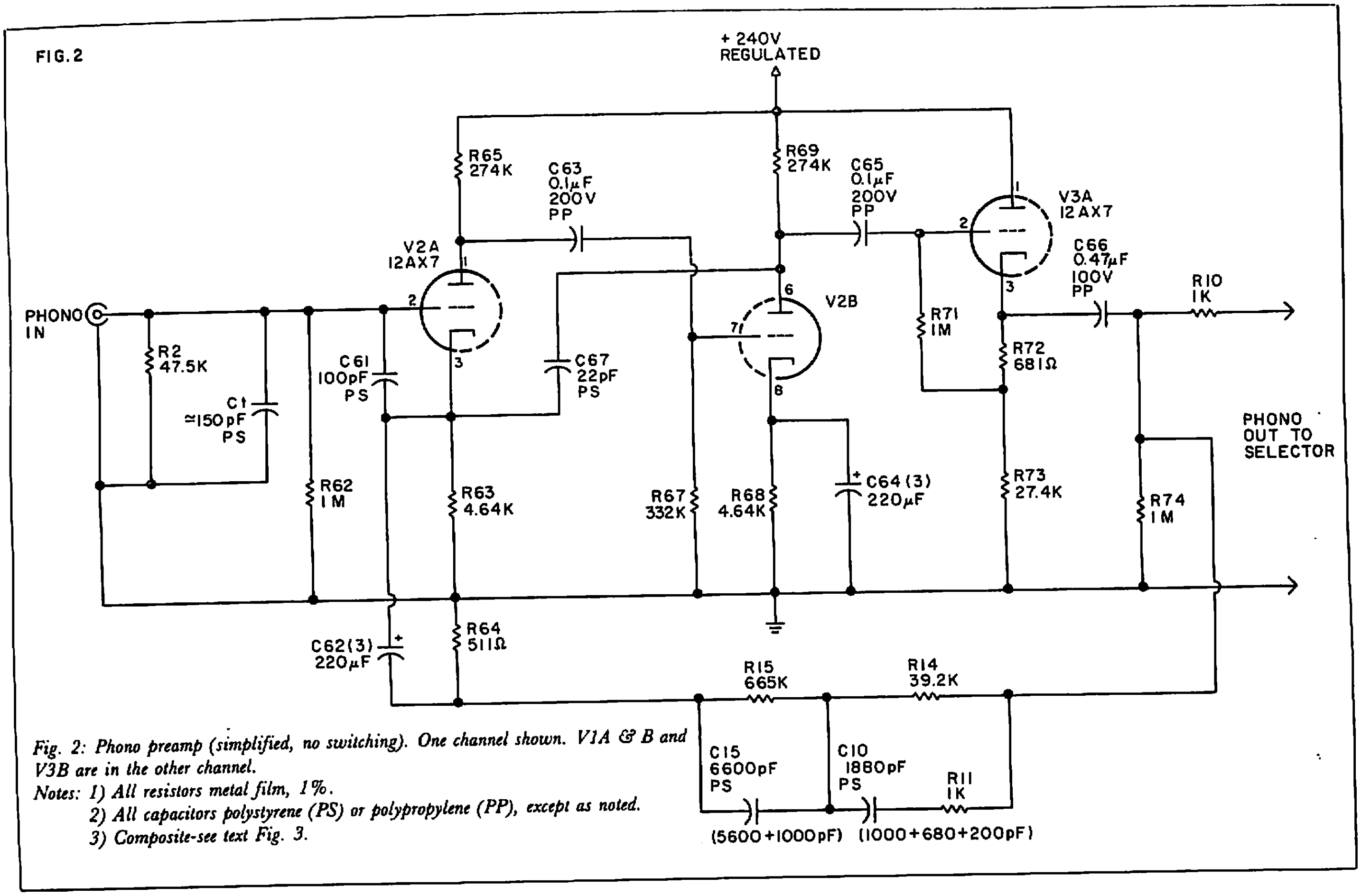

Fig. 2: Phono preamp (simplified, no switching). One channel shown. V1A & B and V3B are in the other channel.
Notes: 1) All resistors metal film, 1%.
2) All capacitors polystyrene (PS) or polypropylene (PP), except as noted.
3) Composite-see text Fig. 3.

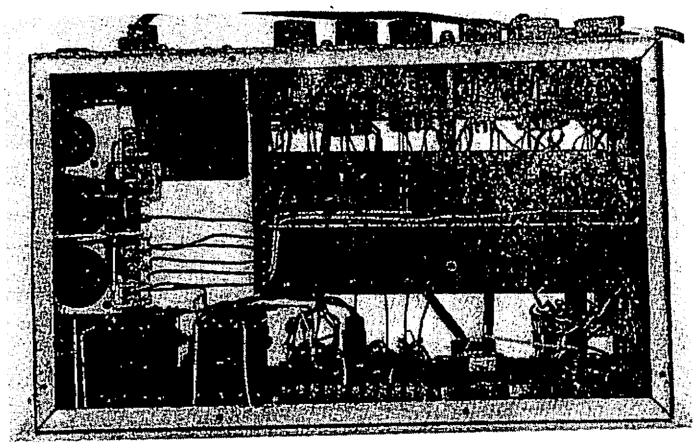

Photo 1A. Interior of the unmodified 7C, resistor side of the terminal board. Power supply is at left, shock mounted tubes are at the top of the photo.

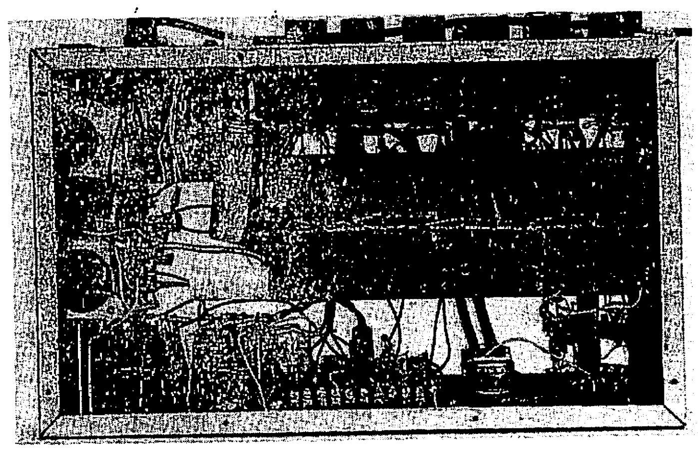

Photo 1B. Modified 7C, resistor side of terminal board. Note added power supply capacitors at left.

Photo 2A. Unmodified 7C, capacitor side of the terminal board.

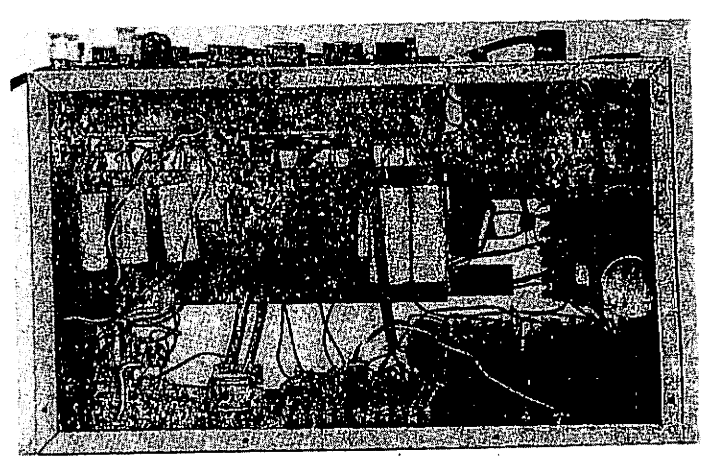

Photo 2B. 7C with new capacitors in place.

Jung/Marsh have been recommending polypropylenes on an all around basis, and polystyrene where applicable[33] (note: Teflon could also be recommended, but is practically non-available to the hobbyist).

As resistors have a variety of grades, so also do capacitors. Among the films, one could rank polyester, polycarbonate and polypropylene/polystyrene in order of increasing quality; as one might rank carbon composition, carbon film and metal film resistors. For this preamp, we recommend only polypropylene (PP) or polystyrene (PS), with qualified use of high quality electrolytics at specified points. In *Fig. 2* the small value caps are PS, the larger ones PP, as noted. C_{62} and C_{64} are composite 220μF electrolytics, that is, a quality electrolytic shunted by high quality film units, in this case 5μF and 0.47μF PP units. This forms a polar coupling (C_{62}) or bypass (C_{64}) capacitor with excellent wideband characteristics.[33]

The output capacitor C_{66} is a relatively small PP type, for reasons of economy. Since this capacitor feeds only high impedance loads, a small value will suffice (as originally used).

The RIAA network, R_{14}, R_{15}, C_{10}, and C_{15} warrants some discussion. *Figure 4* shows the original network component values and type. They can be seen in the stock model 7C's interior *Photo 1A* and are physically located on the EQ switch (SL7E) and the selector (SL7P).

We replaced the original units with high quality metal film resistors and polystyrene capacitors, with values trimmed for best RIAA accuracy. The new values are shown in *Fig. 2* (with the individual paralleled PS values in parentheses). These values are non-ideal from a theoretical standpoint, although a couple are close. Unfortunately R_{15} must be higher than theory predicts, due to insufficient open loop gain. The value shown may thus require further adjustment for different preamps, or tube sets.

Because of this, we recommend that you check for correct RIAA response against a precision inverse network,[12] if you want response varying less than $\pm$0.25dB. You can easily trim the network components working from low to high frequencies in sequence, with one or more iterations. The *Fig. 2* values should be considered as a starting point then, if ultra-precise RIAA is your major objective, and optimized for your specific unit. Non-ideal RIAA is a potential hazard for many similar tube preamps, due to the loop gain problems, which will typically result in the resistor corresponding to R_{15} and perhaps others, being trimmed for conformance, due to interaction. The 1kHz RIAA gain of the preamp is almost exactly 40dB, and only 1.5dB below original gain, due to the altered network values.

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HIGH LEVEL STAGE

The modified high level stage, shown in *Fig. 5*, is simplified by omitting the tone control network and both high and low filters. Comparing *Fig. 1* with *Fig. 5*, you will see that considerable simplification is possible by not using these functions, probably the way most audiophiles are likely to use the preamp.

The same component considerations as in the phono stage apply here as well; that is, all resistors are the metal film types specified, and polypropylene capacitors are the TRW units specified in *Fig. 3*. C_{92} is increased in value to a composite consisting of a 5µF TRW, plus a 0.47µF (similar to *Fig. 3*, but *sans* electrolytic). This will allow extended bass response with lower input impedance amplifiers, such as the 22k impedance of the Hafler DH-200, for example. Some situations may even justify a 10µF nominal size for C_{92}, but we recognize that many will consider such large polypropylene capacitors prohibitively expensive. However, this moves the question into the realm of personal value decisions, on which we cannot comment. Note however that C_{62}, C_{64}, and C_{92} require polypropylenes of only 100V rating which will conserve space and possibly dollars.

As we said earlier, variable controls such as R_{22} and R_{24} can be sources of sonic problems, such as veiling and/or poor definition, and most definitely tracking problems, as described by Saunders[22] relating his experiences with an Audio Research SP3A-1. Therefore, if you are building this circuit we recommend you give serious attention to both BALANCE R_{22} and VOLUME R_{24} controls, regarding their optimum selection.

In our opinion, a near optimum solution to the volume control question is to install one of the multiple-position, finely detented laser trimmed stereo ladder controls now becoming available. These are made by both Alps and Noble, and give excellent tracking performance, as well as smooth but firm detent action. Their only serious problems (for the amateur modifier) are price and availability. Audio Dimensions (8889 Clairemont Mesa Blvd., San Diego CA 92123) sells a 250k version for $40, for those willing to settle for nothing but the best.

Alternatively, and more in line with the budget pocket, Hanifin Electronics (P.O. Box 188, Bridgeport PA 19405) can supply dual Allen-Bradley controls for both VOLUME and BALANCE for $4.25 each. Ask for a 500k dual A taper for VOLUME, and a 1 Meg (or 500k) dual linear, for BALANCE. In the prototype POOGE-1, we used a pair of 500k Allen-Bradley dual controls (see *Photo 4*).

For the rear panel OUTPUT LEVEL screwdriver trim control, a pair of Allen-Bradley linear taper, locking shaft units can be used. These are also available from Hanifin, for $1.75 each. If no gain trim is deemed necessary, this control can be bypassed altogether by connecting C_{91} to the top (or input), and lifting R_{53}. Obviously, this will eliminate any potential contact rectification problems.

HIGH VOLTAGE REGULATOR

The largest single modification step in transforming the Model 7C into the POOGE-1 was in the power supply. We tested a variety of schemes, ranging from upgrading the original simple half wave rectifier to a full wave bridge, various zener regulators, through the final fully regulated circuit of *Fig. 6*. All gave different degrees of improvement and we would say that even further improvement is probably still possible. However, in commending a circuit for wide use we wanted to emphasize ease of setup and reproducibility, as well as good electrical performance. The circuit of *Fig. 6*, is not only simple, easily modified for other voltages, but also expandable into cascades or dual modes.[21]

This circuit uses a National LM317T regulator IC as the basic control element, which is floated upon a zener diode stack (D_4-D_6), which sets up the desired output voltage. Here three 75V/5W diodes are used, biased at a fixed 12mA current level by R_3. This yields an output voltage of just under 240V. The 5W rating for these diodes minimizes their thermal and dynamic impedances.

Output currents up to 15mA can be supplied by IC_1, which is input buffered by Q_1, a high voltage transistor which absorbs input voltage variations. This is absolutely necessary to avoid breakdown of IC_1 (a 40V device); however as a side benefit the pre-regulation of D_1 increases the line rejection of IC_1 by a factor of several thousand. Readers may note some similarity of this use of the 317 to that used in the PAT-5/WJ-1A modification![11]

Although the circuit concept is basically simple, several factors are absolute *musts* to ensure proper function, as well as for safety reasons. These amount to a list of do's and don'ts, which should be followed rigorously if you expect it to work.

First, the circuit likes to be loaded in the 10-15mA range; and this is optimum

Photo 3. Closeup of two tube sockets in the modified 7C.

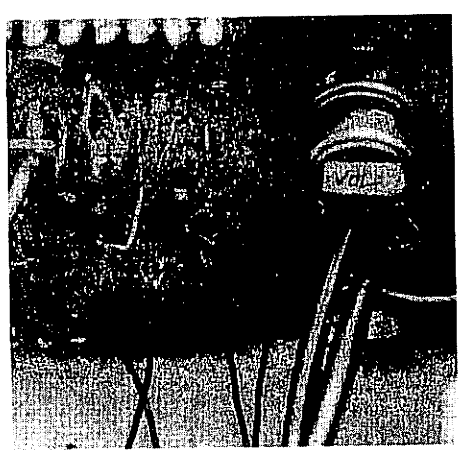


Photo 4. New Allen-Bradley balance and volume controls in the modified 7C.

FIG. 3

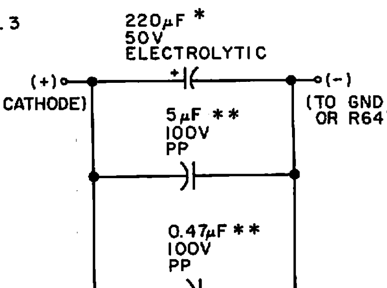


Fig. 3. Composite capacitor connection (used for C62A, C62B, C64A, C64B).
Suppliers:
**Mepco/Electra*
Sangamo
Siemens
***TRW X363UW series*

FIG. 4

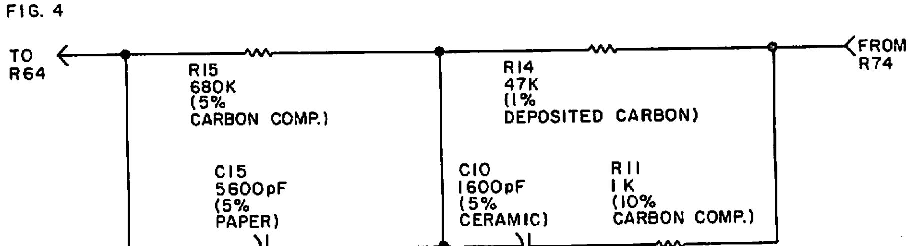


Fig. 4. Original RIAA network.

for the POOGE-1's 12mA total drain. For other load conditions, use a resistive bleeder to ground on the output to make up the difference. If you require a load of more than 15mA, a heat sink for Q_1 is definitely in order.

In the Model 7C as modified for the full wave bridge, a new 100µF/450V input filter (C_1) yields an unregulated input of +350V. This means the regulator must drop about 100V in this case; for other cases adjust R_1 to provide 2 to 3mA of current in D_1, to properly bias D_1-Q_1. D_2 is a IN4007 safety clamp diode, do not omit it, or skimp on its voltage rating. Similarly, D_3 serves as a protective clamp for IC_1; do not omit it either. C_1 can be a can type, replacing the original C_{102}.

Photo 5. DC filament voltage regulator mounted with insulating washer and silicon on the rear panel of the 7C.

With a 10mA load, this circuit has an output impedance of 20 milliohms or less below 1kHz, rising at higher frequencies due to the LM317. A large Rubycon 600µF/360V photoflash capacitor is used for C_5 to maintain low impedance at higher frequencies, shunted by C_6, a relatively large film type (preferably polypropylene). C_3 and C_4 maintain a low impedance at the LM317 ADJ terminal to bypass zener noise. C_3 is a photoflash capacitor as well as C_5; and the value specified results in a controlled surge turn-on of about 6-7 seconds, which minimizes stress on components.

If you use surplus capacitors for C_3 and C_5, we recommend forming them before use (see *TAA Letters* 4/79, p. 58, or the general procedure in[34]).

Some specific comment on efficient selection on C_6 and C_4 is warranted. Both see a continuous 240V, so their terminal voltage should be appreciably higher, say 300 or 400V. PP types are preferred, then polycarbonate or polyester. They should have good HF characteristics, extended foil construction, low loss terminations and leads (such as OFHC copper), and a low and stable ESR. All these criteria are met in the TRW X363UW types, which is available in a 400V rating.

Physically, both C_3 and C_5 are large, and may be difficult to install. C_5 was mounted using a round cable clamp on the single hex bottom support visible in *photo 1B* (the photo was taken before C_5 was added, however). C_3 may not be as readily available in a photoflash style, but can also be a comparable rated computer grade electrolytic mounted in the wafer first occupied by C_{103}. The exact value is not highly critical, and anything over 200µF will minimize zener noise and provide a controlled turn-on. The smaller components of the regulator can be fitted to a pair of 5- or 6-lug terminal strips at a suitable chassis location. Sources for the capacitors are listed at the end of the article.

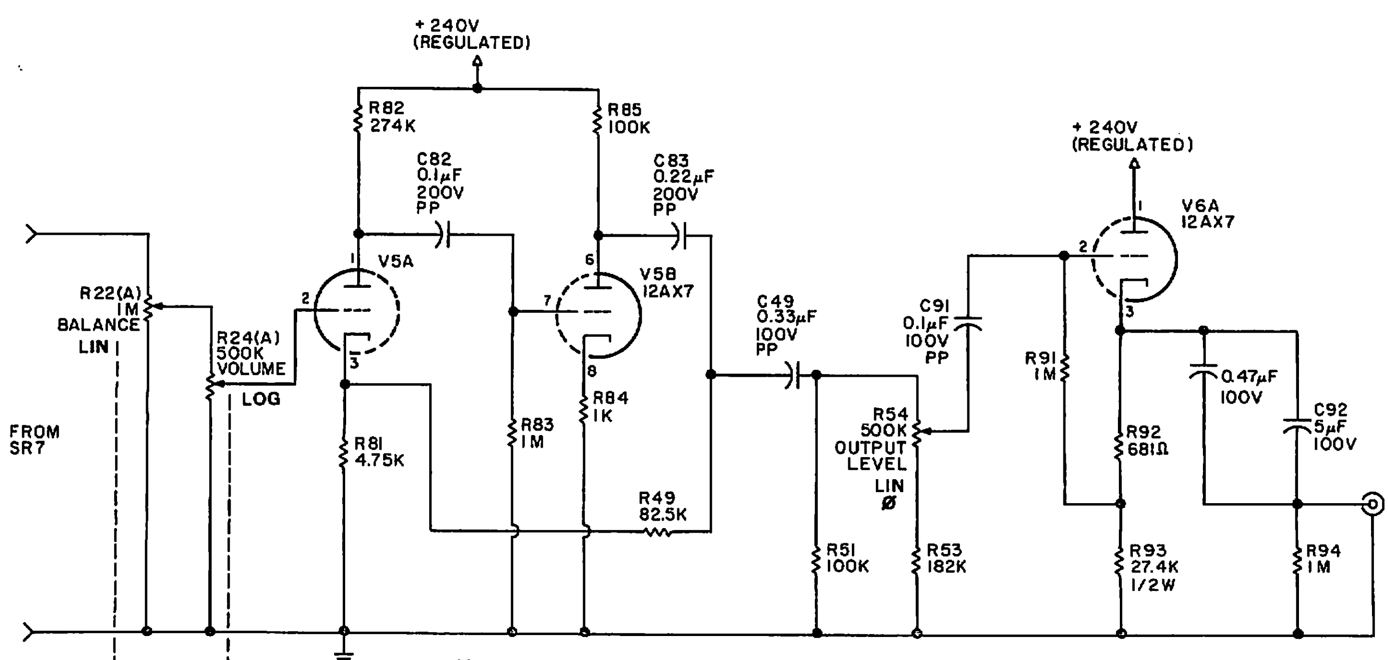
R_2 is a safety protection resistor for Q_1, and should be a 2W rating to withstand surges. Q_1 can be either a MJE3439, or where space allows the TO-3 MJ-413. Either type should be heat sunk to several square inches of metal, using grease and washer. The chassis outside wall will work well for this, for the MJE 3439.

We chose the voltage regulation level of 240 volts for a number of reasons we consider to be valid. First, this level is not far removed from the original voltages, so minimal operating point shift is introduced. Second, in keeping with the original Model 7C's concept of minimal stress, it allows lower voltage components to be used—this being particularly germane to large value film capacitors. For example, the higher voltage, large value PP units are simply prohibitive to the amateur builder, in terms of size, cost and availability, and this is not likely to change drastically in the future. The lower voltage level of 240V allows the builder to use more reasonably sized and priced units.

We recognize that the vacuum tube

Continued on page 34

FIG. 5



Notes:
1) All resistors metal film 1%, except as noted.
2) All capacitors polypropylene.

Fig. 5. High level stage (simplified, no switching), one channel shown. V4A & B and V6B are in the other channel.

THE MODIFICATION—PART II

Continued from page 31

preamp trend over the last few years has been towards ever-higher voltage levels and complex tiered regulators. We are not by intent challenging this precept, but we do believe that other techniques are no less valid sonically, and perhaps even more desirable because of longer component life. We think the original Marantz Model 7C design goal of long life is a most desirable one, and believe the POOGE-1 modifications can only enhance that concept.

POWER DISTRIBUTION

With a single central HV regulator, the three HV feed points of the two stereo channels are tied together at the +240V output, or main regulator point. This is simply achieved by the WHT/YEL/-RED wires, which terminate on the long terminal strip. The energetic audiophile may wish to try a dual mono approach, powering two *Fig. 6* circuits from the +350V unregulated point. We have not yet tried this in the POOGE-1.

However, by making this comment we do not mean to apologize for the circuit as it stands, since if its regulation impedance is compared to a simple emitter-follower (such as the SP-3A-1 or Dave Vorhis' second PAS mod), it is about two orders of magnitude better. Inasmuch as those two circuits were widely recognized among audio amateurs as great strides forward;[3,4,6,21] it would seem to follow that further improvement in kind would be valuable. So, we believe the circuit of *Fig. 6*, installed and properly operating in a previously unregulated tube preamp can serve as an aural awakener to those without previous experience with power supply regulation improvements. In fact, should you be debating where to start on these mods, we suggest doing the power supply changes first.

It should be an eye-opener (ear-opener?), and will also allow you to hear the remaining mods better.

HEATER REGULATOR

As a final touch to the power supply section, the already DC operated tube heaters were converted to a regulated hookup, using a TO-220 3 terminal IC regulator as shown in *Fig. 7*.

With the six tube series-parallel operated heater string of the Model 7C, 18.9VDC at a current of 600mA is required. In the original circuit (*Fig. 1*) the excess DC voltage was dropped in a 3-section RC filter; R_{101}, R_{102}, and R_{103} plus the pilot lamp, in conjunction with the capacitor C_{101}. Nearly ten volts total is dropped across this string, easily enough to bias an IC regulator conservatively.

In the revised circuit R_{101} and R_{102} are wired in parallel as a surge limiting input resistor to parallel connected C_{101}. The input of the regulator is taken after the pilot lamp R_{103} connection. Capacitors C_1 and C_2 stabilize IC_1 against possible RF oscillations.

Where a regulated 18.9V is required, no standard fixed output 3-pin regulator exists to fully satisfy the need. In this hookup, we use a commonly available 15V type, the LM340-15T, with the difference voltage supplied by a zener in the GND leg. D_1 is shown nominally as a IN4732 (4.7V, 1W) type, but any zener of similar wattage with a terminal voltage which adds to that of IC_1 to yield 18.9V is O.K. Select D_1 then, to cancel the specific voltage tolerance error of IC_1, and yield a net total voltage of 18.9V.

Yes, true, the "4.7V" of D_1 added to 15V yields nominally more than 18.9V, but D_1 is not being operated at the test current appropriate to 4.7V rating, but actually less, about 5mA as furnished by IC_1's bias current. Minor adjustment to heater voltage can be realized by adding an extra biasing resistor, from IC_1's OUT to GND pins; a 5k resistor for example, will add 3mA of current to that already present in D_1, and raise the overall output.

This basic scheme of bootstrapping an IC regulator for voltage adjustment is applicable to other terminal voltage units as well; 5V etc. Alternatively, an LM317T unit could be used as well with resistor-divider adjustment for 18.9V. The heater regulator IC is installed on the back panel near the line cord, and can be seen in *Photo 5*. Use a mica washer and grease, or a pre-greased silicone pad, along with a shoulder washer. Insulate the leads with spaghetti or heat-shrinkable sleeving.

Make final adjustment of D_1's trim to IC_1 mounted as above, and all tubes fully warmed up. With the heater voltage thus established, there will be no gain changes with power fluctuations, and different tube types can be validly compared to one another. And the controlled surge warmup and overvoltage protection will have a positive influence on tube life.

OUTPUT MUTE CIRCUIT

A simple modification of the *Fig. 7* heater rectifier circuit provides a lightly filtered and unregulated source of 24VDC across C_3. This voltage can power an optional 24V relay circuit to mute the preamp output on turn-on and switch-off, preventing surges at the power amp input.

The mute circuit shown in *Fig. 8* consists of a simple time delay circuit, which opens a pair of NC relay contacts after an initial time delay at switch-on. At switch on, the output end of the 475Ω resistors are grounded, shorting the output to silence, and also providing a low Z charging path for the high value output coupling capacitors. After the time delay of R_1-C_1 times out, D_1 breaks down and drives Q_1 on. This opens the short across the output; allowing normal signal operation. The normally operating signal path does not go through the relay contacts, so they are not a potential signal degradation.

At switch-off K_1 drops out rapidly, due to the light filtering of the 100µF capacitor (C_3 of *Fig. 7*). This mutes the output before the large output capacitors have time to pass transients. The user may mute manually at any time, by opening the collector path to Q_1.

This general circuit, can be adapted to any preamp with 24 to 30V of DC power available to drive K_1. The original prototype was fitted neatly into a Dyna PAS and operated from the 22V supply.

MISCELLANY

We incorporated some changes during the development of the POOGE-1 which are neither component quality upgrades nor power supply related, but which we consider nevertheless important. Some readers may wish to make modifications which we did not make, but we'll mention them anyhow, for the sake of thoroughness.

After installing all the electrical mods and living with the unit for a period of several weeks, we applied "Cramolin" contact cleaner/preservative to all switch contacts, input/output jacks, and tube sockets. For those of you not familar with this wonder substance, Cramolin is a fluid which is applied to electrical contacts for the purposes of lubrication, cleaning and preservation. It breaks down the oxides which form on nearly all metal surfaces, and enables greater integrity of current flow. Obviously this is of fundamental significance to an audiophile, in a manner we think is similar to record cleaning and preservation agents for your discs. In our opinion you should not be without it, and should use it on *all* nonsoldered contacts—from head shell pins to the speaker.

Although used for years by the military, Cramolin has recently been discovered by audiophiles, and described in articles in *Audio Dimensions* "Update" and Len Hupp's *Audio Horizons*. A 2 oz. vial of the RED fluid (most generally useful) can be purchased direct from Caig Labs, P.O. Box J, Escondido CA, 92025 for $3.50 plus postage. [Orders to Caig must be $10.00 minimum, however.] Or, inquire at your local audio dealers, they should have it in stock (if they don't, suggest that they do so). [Old Colony will stock Cramolin—Ed.]

Applied to contacts as described above, Cramolin stabilizes and improves sound definition. The makers advise the user to apply as little as possible to each contact for best results. In the case of very dirty or deteriorated con-

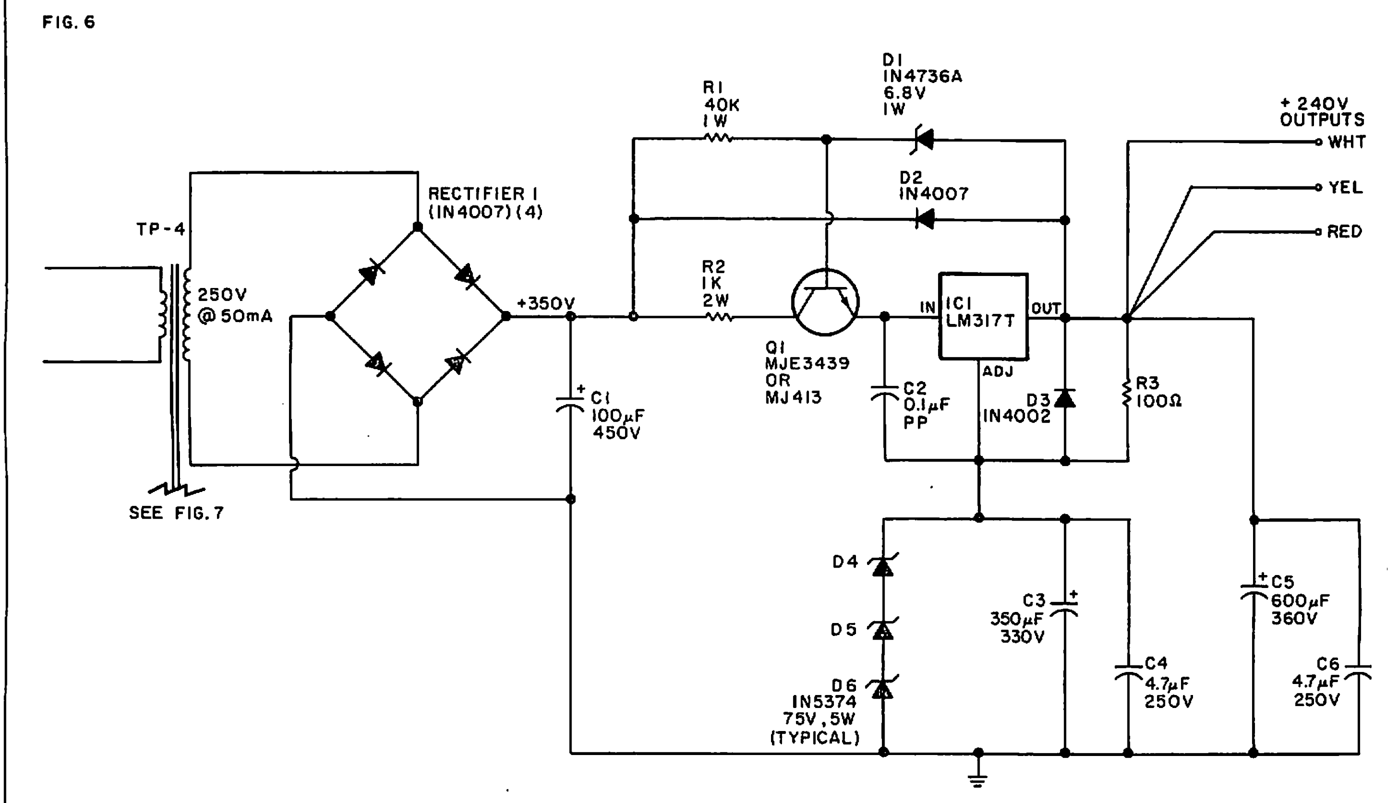


Fig. 6. High voltage regulator circuit.

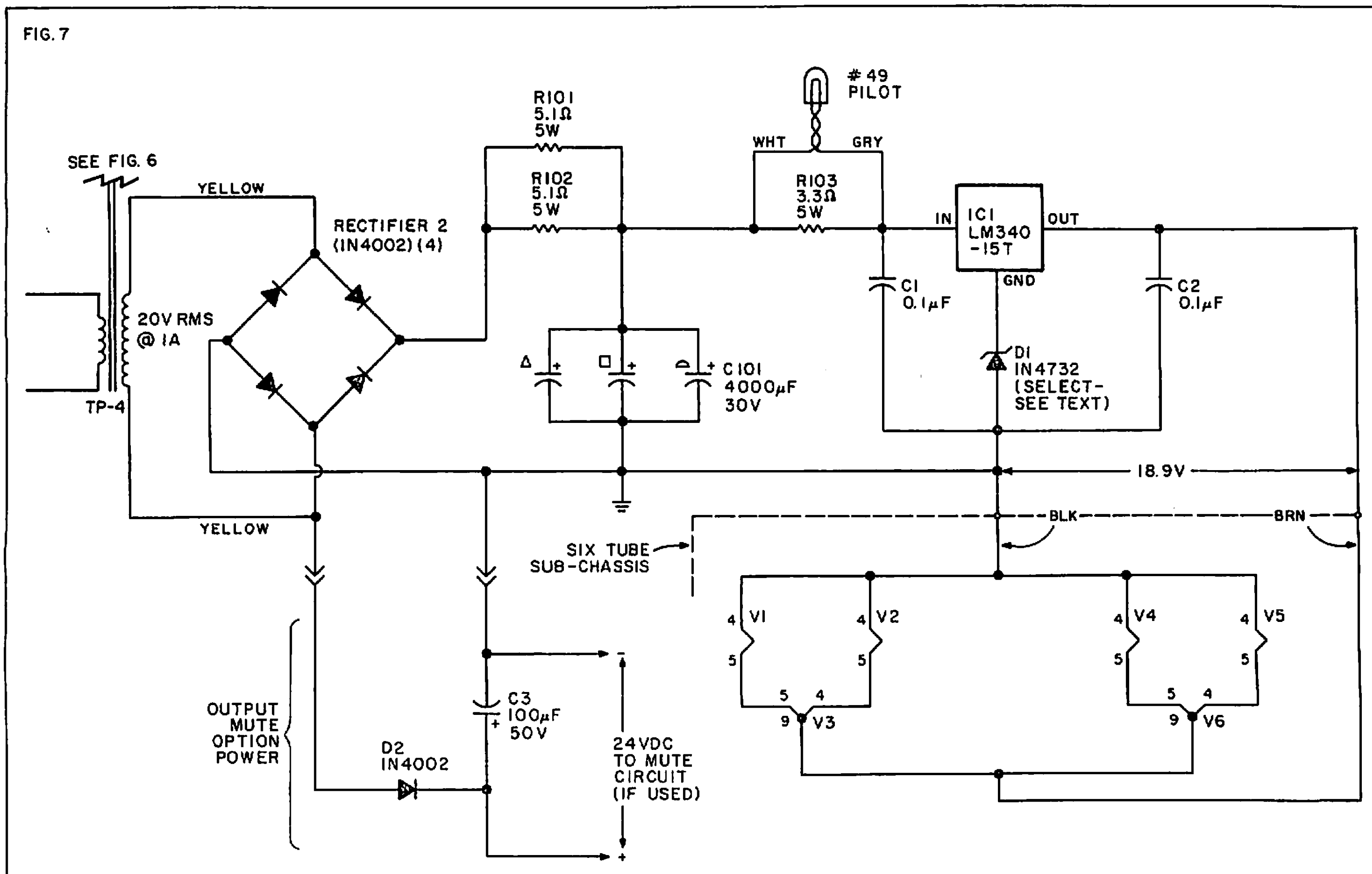


Fig. 7. Heater regulator revision.

tacts, the improvement can be dramatic—from harsh and fuzzy to smooth and sweet. Everyone has suffered from "connectoritis" problems with speaker connectors at one time or another. Similar sonic degradations of less degree can also occur elsewhere in the system at any metal-to-metal contact interface, where Cramolin will minimize the potential problem and make for better sound.

We tried brands of 12AX7 tubes in the POOGE-1 after all voltages had been regulated and the other mods installed. The best of them (as measured) appeared to be Amperex (Great Britain) types, which improved the high level distortion from 0.07% to just over 0.01% @ 3V out, compared to RCA (Great Britain) tubes. We also tried Valvo tubes (West Germany), which were superior to any others in terms of image and ambience recovery. We would appreciate feedback from the field from others who try these mods, as there may be other tubes desirable also (in terms of price and availability, as well as sonics).

An interesting thing which fell out from the power supply and resistor excerise was a rather dramatic increase in phono signal-to-noise (S/N), using the Amperex (UK) tubes.

Things not attempted with the POOGE-1: we did not alter the switching, simplify the signal path, or use better contacts. Also, we retained the original tin plated input/output jacks. These decisions were, in some technical senses, tradeoffs, but were made to retain the outside appearance and functionality of the piece, which we feel is a classic well worth preserving. Scratch builders not constrained by such a rationale might opt to use better switches and jacks, with perhaps even better results.

CONCLUSION

After so lengthy a discourse on how to improve a venerable old preamp, we might ask, "What is the message of this article?" The answer: component quality can have a distinct effect on sound. Given a topologically "correct" circuit— tube, transistor, or IC—the passive devices in the circuit can make or break it. We all know of correct circuit designs that sound "bad;" but, to complicate matters more (the nature of standard steady-state testing being what it is), their specifications are "good." Specs good; sounds bad, we say. Often it is the resistors, capacitors, and/or power supply (as well as the amplifying devices) that misbehave under transient conditions. We have heard some tube, transistor, and IC preamps sound quite different; but after performing the type of modifications described here, they sound very similar.

We believe the various interactions between the amplifying devices and the less than ideal passive devices, as well as the active device differences themselves, give transistorized preamps what has become known as their "hard" sound, tube preamps their "sweet," or more euphonic sound. These stereotypes have arisen not only because of topological differences, but also because passive devices typically chosen have been less than ideal, due to considerations of cost (carbon composition resistors, minimal or zero power supply regulation and/or space (tantalum capacitors).

With the substitution of audio components that most closely approach the theoretical ideal (TRW polypropylene capacitors, CGW 1% metal film resistors, and very tight, wideband power supply regulation), various topologically correct preamps can yield their designed audio (as well as test) performance. If we take a sophisticated circuit like the Marantz 7C, one audio buffs still considered near top-of-the-line as recently as five or six years ago, regulate the voltages and replace the twenty-year-old resistors and capacitors with the best currently available, we should get a stunningly good preamp. And we do: POOGE-1.

This article's second message: trust your judgment. Our initial intent was to set up an A/B double-blind listening test comparing a "stock" Marantz 7C to the POOGE-1. We are extremely confident that, though the two preamps have been trimmed to within a .2dB of RIAA accurate, normalized for phase and gain, *they still sound distinctly different.* Which leads us directly into the morass of "proof," which we will doubtless be asked to supply. To such demands we reply that we have no confidence in currently reported testing procedures purporting to gather statistically significant evidence that such normalized amplifiers all sound alike. What can be said of two amplifiers "proven" to sound alike, one of which *irritates* in the long term? Does the irritating amplifier represent golden ear hallucinations, or has the double-blind test failed to identify the irritant? One can adopt either stance, but *proving* either is quite another thing entirely.

Many highly respected members of the audio community have not accepted as either valid or relevant the current A/B double-blind procedures. Is what is claimed to be actually measured; are the null results truly indicative of no audible differences? Indeed, there is neither standard methodology, nor vocabulary, among the proponents of such tests.

We make these statements not to provoke argument, since we fully appreciate that the positive double-blind test results reported have not been universally embraced. The pitfalls of such testing are many, and though experts have wrestled with the problem for years, it remains unresolved. We think

FIG. 8

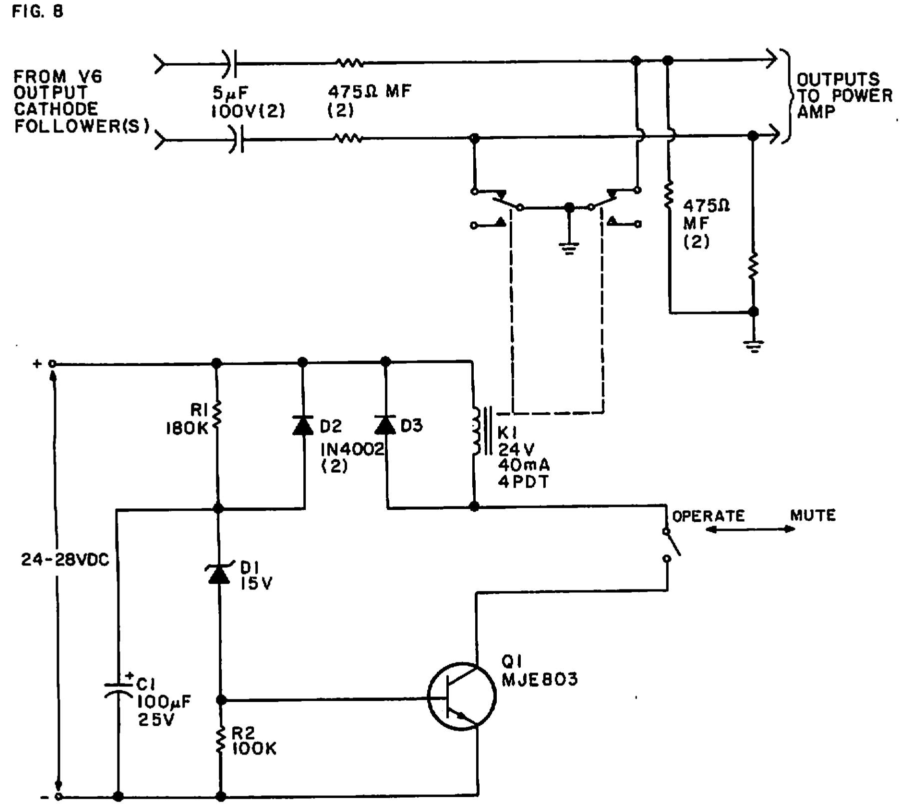


Fig. 8. Output mute circuit.

this fact speaks volumes on the complexity of the issue, and should caution all of us toward patience.

Until there is procedural consensus throughout the audio community, we will continue to work in our fashion towards what will ultimately be a methodologically correct (according to Donald P. Campbell and Julian C. Stanley, *Experimental Quasi-Experimental Designs for Research*, 1963, Rand-McNally, Chicago) research design, one that demonstrates consistency over the short and long terms, and one that is both valid and reliable. We will remain alert to new approaches; but we realize we are not listening-test designers, and we leave that formidable task to others. In our judgment the difference between a "stock" Marantz 7C and the POOGE-1 is the difference between very good and excellent; similar to the differences between the best moving iron and the best coil cartridges.

The POOGE-1 does not sound radically different however, than the Marantz: in fact it sounds much the same in many ways (dynamic range, openness, sweetness). The differences we are examining are the last few percentage points of performance in expanded scale, as if we were using logarithmic paper. The asymptotic improvements, as we approach optimum, must be examined as if under a microscope. These improvements may not be apparent with a system that is not highly analytical, nor to listeners who are not finely tuned to those real differences which distinguish the very good from the excellent.

The Marantz 7C is very good! (We know one audio salon proprietor who continues to prefer it to anything in his store.) The POOGE-1 is noticeably less shrill (and less fatiguing), has tighter bass, better imaging, less blurring, and handles crescendos more effortlessly than the stock Marantz. To illustrate the difference, Donna Summer's "Need-A-Man Blues" from her *Love to Love You, Baby* album (Oasis records), is the best example we could find. Through the Marantz the sibilants were so "shushy" we could barely understand the words, and we found it irritating; through the POOGE-1 it was nearly pleasant, though apparently "hot" by engineer's design. On other musical selections (harpsichords, string quartets), the Marantz was "brighter" and less natural, in our opinion.

Which leads us to our final message; we hereby qualify this entire article as the personal opinions of the authors, as audio hobbyists—no more, no less—for whatever that may be worth. To the audio amateur with a Marantz 7C (or some other golden oldie tube gear), we suggest these modifications and solicit your comments on their effectiveness. We could modify further, as suggested above; but we'll leave additional mods to the readership, reportable in these pages. We hope to encourage more cooperation among audio hobbyists, aiding each toward better listening. In time, our ears alone must be the final arbiters, and we'll bet you the cilia on our basilar membranes these modifications will propel your old tube gear light years (well, twenty years anyway) ahead. The POOGE *knows*. □

ACKNOWLEDGEMENTS

It is a tribute to the original work of Saul Marantz and Sid Smith that even today their Model 7C holds its own so well against current preamps. For such a classic we can only say thank you!

We also appreciate Sid Smith's helpful comments on the preamp's design during this article's preparation.

We'd also like to thank Dick Marsh, Rod Rees and Dave Vorhis for commenting on the article.

SOURCE INFORMATION

Surplus and new electrolytics, film capacitors, and metal film resistors:	Tek-el 27 Gill St. Woburn MA 01801
	Chaney Electronics PO Box 27038 Denver CO 80227
	Hanifin Electronics PO Box 188 Bridgeport PA 19405

Continued on page 56

KIT REPORT: DELTAGRAPH

Continued from page 44

hand. Frequency response tailoring generally requires only small adjustments anyway; I wonder why these units provide such a large range of adjustment.

The equalizers make even Columbia records somewhat listenable, and are useful with almost all records. The American records that need no equalization are those you might expect, such as direct-to-discs and, to my surprise, new Nonesuch releases. Given the current state of the recording art, an equalizer is a necessity in any good system using disc recordings. I'd be lost without it now that I know what it can do. □

MANUFACTURER'S SPECIFICATIONS

Frequency Response: Within ½ dB from 20Hz to 20kHz, 3dB 5Hz to 80kHz with all controls centered and one volt input signal. See *Figure 2* for boost and cut curves.

Total Harmonic Distortion: Less than 0.05% up to 2 volts rms output 20Hz to 20kHz, controls centered, 10kΩ load. Less than 0.1% at any input or output level up to 1 volt rms, any control setting, 10kΩ.

Hum and Noise: 90dB below 1VRMS input signal, 600Ω source, output weighted -3dB at 20Hz and 10kHz, controls centered or fully boosted.

Band Centers: 31.25 Hz, 62.5Hz, 125Hz, 250Hz, 500Hz, 1kHz, 2kHz, 4kHz, 8kHz, 16kHz,(±10%) Nominal "Q" at full boost or cut is 2.5 (±10%).

Output at Clipping: 10VRMS (1kHz) single-ended output, 20VRMS balanced output into 10kΩ load.

Output Impedance: 300Ω per single-ended output, 600Ω balanced output, DC coupled. Maximum output decreases and THD slightly increases for loads below 2kΩ.

THE MODIFICATION—PART II

Continued from page 37

SOURCE INFORMATION *continued* . . .

	Old Colony Sound Lab Box 243 Peterborough NH 03458
Corning Resistors and TRW Capacitors	Precision Audio Consultants Box 854 Carmel IN 46032
Technical Information	Corning Electronics Corning Glass Works Houghton Park, A2 Corning NY 14830
	TRW Capacitors 301 W "O" St. Ogallala NB 69153

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