A Passively Equalized Phono Preamp

by RICHARD N. MARSH

Traditional preamp designers deal inadequately with many problems: feedback, accurate equalization, symmetry, DC offset, input loading, polarity, crosstalk, power supply and grounding. Here's one designer's approach to the questions.

THIS ARTICLE describes a "passive" RIAA preamplifier. I have paid close attention to its operating requirements and parameters, as well as to the devices and components used to create it. It produces superior sound; but it is neither inexpensive nor very easy to build.

I will forego the standard approach to describing its circuitry ("R_4 does this and C_9 is for that," etc.). Instead, I'm going to describe the less obvious considerations and an approach to, or philosophy, of design. But first I'd like to digress a bit.

TRADITIONAL ANSWERS

The preamplifier shown in *Fig. 1* has been the mainstay of many good products for quite some time. The general idea is to provide open loop gain high enough to minimize noise. The RIAA network needs about 60dB at low frequencies. Add another 20dB for stability and distortion reduction, and we have 80dB. Many circuits, particularly the IC types, meet and exceed this requirement at very low frequencies.

Using this approach, the builder reduces noise in the input stage with low collector currents—100μA is a frequent choice. But this considerably limits the stage's slewing ability; in addition, the preamp's open loop bandwidth is usually only about 100Hz.

In the light of much recent investigation into audio distortion mechanisms, a good deal of this traditional design approach is questionable and makes it difficult to meet the challenge presented by newly developed requirements and insights. Feedback is one important matter. The amount of negative feedback ("active" RIAA) differs with varying frequencies: how much it differs depends on the RIAA closed-loop gain versus frequency and the shape of the open-loop gain versus frequency curves. Negative feedback does not reduce all harmonics by the same amount, low-order harmonics being reduced more than high order ones; low amounts of negative feedback can actually increase the high order content. Perhaps these varying amounts of feedback accompanying the "active" RIAA amplifier contribute to its discontinuous tone quality.

EQUALIZATION PROBLEMS

Another concern is that error correction and phase/amplitude compensation (RIAA) in the same path leads to a compromise situation. The error components (distortion) of the output signal are also subjected to the RC networks' phase/amplitude action. This leads to somewhat less than ideal error correction when applied to the inverting (−) input port.

Active RIAA circuits may also have an inherent problem I'd like to get rid of. This type of feedback has two functions, RIAA compensation and error correction. If we think of the preamp output as composed of two components, the pure amplified signal and the added distortion, we'll visualize the problem more clearly.

The pure (undistorted) amplified signal is fed back through an inverse RIAA network for flat response at the output. The distortion components generated by the imperfect amplifier are fed back to the same input port but changed in amplitude and phase by the RIAA network. A better solution, therefore, would be to separate the error correction from the RIAA network, as does a "passive" RIAA preamplifier.

Distortion is greatest in the single-ended driver stage Q_3 (*See Fig. 1*) because this stage must usually drive the output stage's relatively low impedance and/or swing the full power supply voltage. Attempts to remove the distortion by such means as bootstrapping and active current sources produce nowhere near the improvement achieved with push-pull or symmetrical designs.

PASSIVE ALTERNATIVES

In a "passive" RIAA phono amplifier the RIAA network is not part of the feedback circuit, but is simply an RC circuit placed between two gain stages. Since we no longer have to get all the gain needed from one stage, we can reduce open loop gain while increasing open loop bandwidth to cover the whole audio range and beyond if we wish.

The best amplifier circuit is balanced and symmetrical, thus offering the lowest distortion potential; examples are the differential and complementary-symmetry push-pull. Operation must be Class A throughout. With discrete circuitry we can run at higher currents and voltages, thereby reducing the signal's power to change device parameters under dynamic signal conditions. It also allows the devices to operate up on the flat portion of the transconductance curves.

Achieving the full potential of any symmetrical stage requires component devices matched at all levels. Devices are often matched at their idle currents alone, but this givesonly one reference point. They must also match at the current level produced by peak expected signal swings. (Relatively high idle currents, of course, minimize the range of current swings.) If two devices match at both levels, they'll do a good job of tracking each other between the two operating extremes. Selecting devices matched at only one operating point may lead to the pair going off in different directions when a signal is applied—i.e., a differential error occurs between the quiescent and peak points and distortion increases, especially even-order distortion.

Matched pairs also offer better thermal tracking, necessary for low drift and offset in direct-coupled designs. Such designs offer low distortion in many inconspicuous ways. The topology used here allows the use of monolithic matched dual devices which eliminate any need for individual selection and testing and provide superior thermal balance.

CAPACITOR BAN

The use of DC coupling provides several ancillary benefits, such as eliminating the cost and distortion of coupling capacitors (yes, capacitors do introduce audible distortion). Equally important is the reduction of envelope and group delay distortion[3], which can be significant in AC amplifiers. These types of distortion have a marked effect on low frequency tone quality. Envelope distortion can also be heard in the middle frequencies, being especially noticeable in solo piano recordings where rapid attacks seem to lose clarity and sound muddy.

When we analyze the output signal equation for THD into a Fourier series, a DC item appears in the equation. If we measure THD with a sine wave this item remains constant with respect to time and therefore does not appear in the measurement. But when we feed audio (music) signals into an amplifier, the DC changes in relation to time. This fluctuation causes adverse effects in the form of low frequency content not found in the original signals. This pheno menon's discoverers call it DC distortion, and think it exists in amplifiers with a gain difference between the input signal's positive and negative polarities; they also suspect it is closely related to even-order harmonic distortion.

I need only say that envelope distortion which includes DC distortion cannot be reduced in AC amplifiers simply by reconstructing the circuits into a direct-coupled design, nor by forcefully eliminating capacitors from feedback circuits. The various methods I use in this DC preamplifier help to reduce envelope distortion; consequently, no signifi-

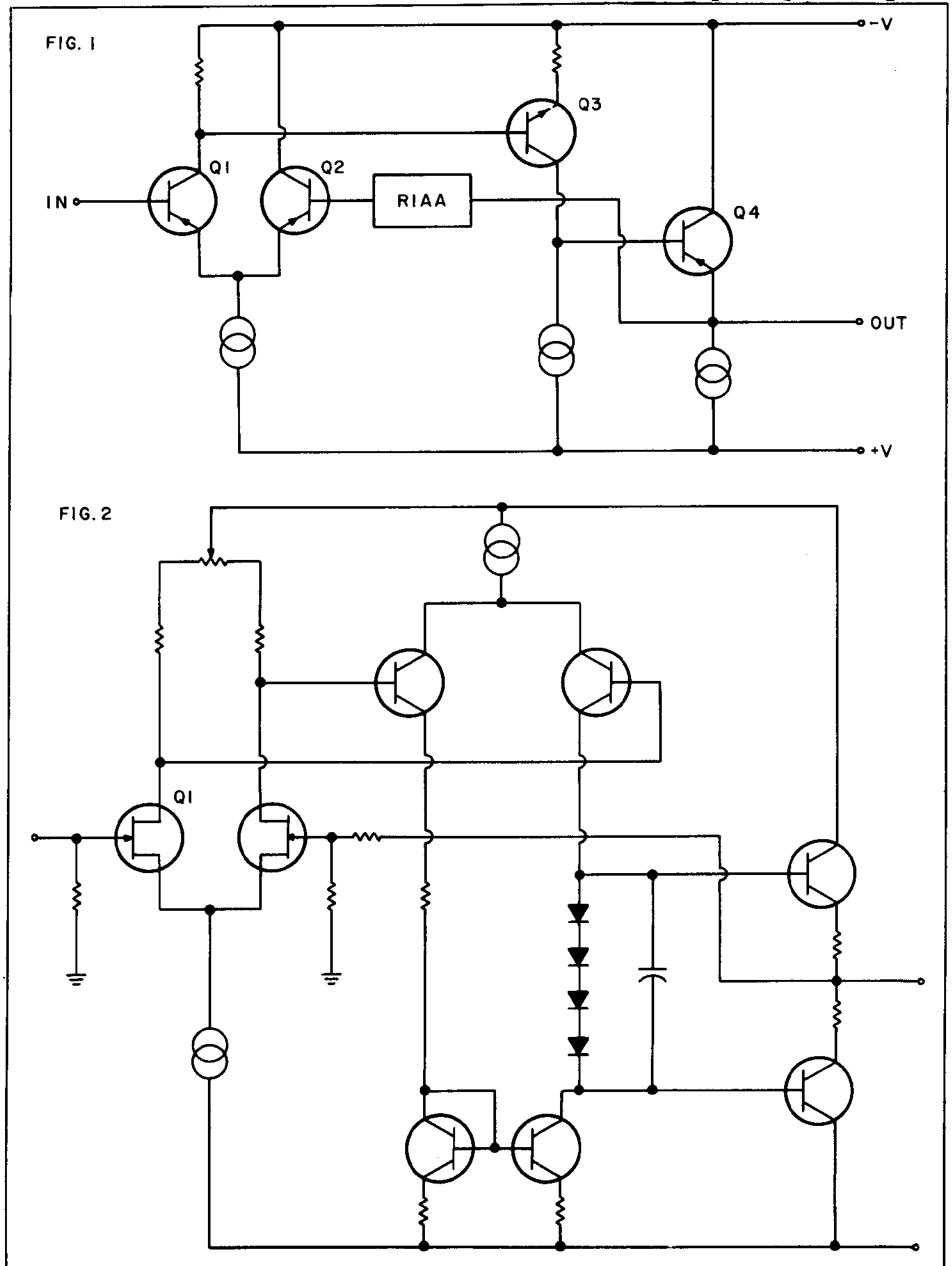


Fig. 1. Typical active phono stage topology.
Fig. 2. Basic phono stage circuit diagram.

FIG. 3

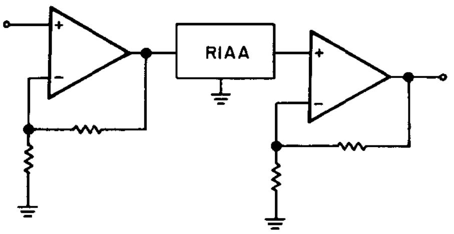


FIG. 4

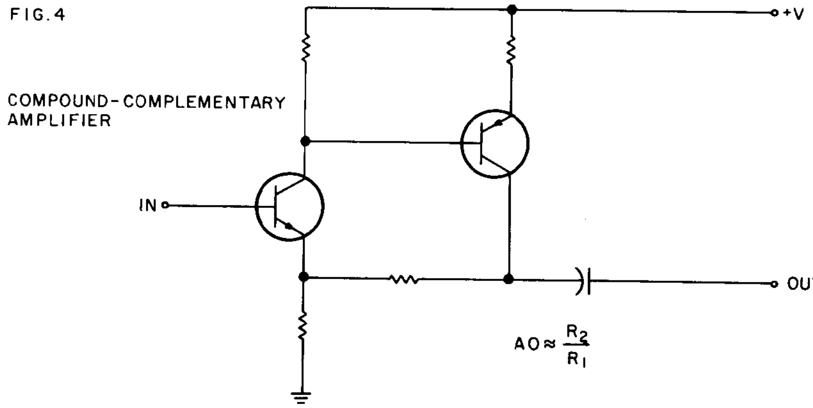


Fig. 3. Block diagram of a passively equalized phono preamp.
Fig. 4. A compound-complimentary amplifier.

cant changes in such distortion will occur even if we include a coupling capacitor to turn a DC amplifier into an AC one. However, if you think such capacitors are useful, then for minimal distortion they must be of the low dielectric absorption type.

A DC amplifier must have very little offset voltage at its output, and the offset must not vary with temperature variations. Do not try to achieve a zero volt DC output by introducing an opposite voltage to compensate for an inherently unbalanced stage. Zero VDC is a result of a well-matched, balanced, symmetrical amplifier, which provides the lowest distortion. Well-matched devices produce an audible improvement, immediately apparent as increased smoothness and airiness with greater ability to resolve details.

FET USAGE

FET inputs solve a few problems with ease. An FET input won't load the RIAA network, so it maintains accurate frequency response, allows the use of more idle current, and can give better SID characteristics. But you'll ask: "aren't FET's said to be noisy at low impedances?"

Some indeed are noisy, but by no means are all of them these days. The E111 performs well, as does the 2N6550. The E111 is a low noise switching FET; its high mutual conductance can give very low levels of distortion with small amounts of local feedback. The noise spec. for the 2N6550 (*input grounded*) is 6nV/√Hz @ 10Hz.

What really matters is what happens when we connect a phono cartridge. With magnetic coil input transducers a resonance arises between the inductance and the load capacitance and resistance, causing a peak in the noise spectrum's 10-20kHz region.[8] This peak noise can be associated with an impedance increase of 100kΩ or more. A bipolar transistor operating at 100μA collector current will usually have lowest noise in the 200Hz-2kHz region. FETs can be very good at 1kHz/1kΩ and may be even better at the 10kHz region where cartridge noise is greatest. Because our hearing is more sensitive at higher frequencies, an FET can sound quieter than a bipolar which measures as well or better with a 1k input terminating test resistor.

Noise should, of course, be low enough to be unnoticeable. Clean program material seems brighter and more spacious with noise added. Many designs start with an effort to achieve the lowest noise possible, and usually accomplish this at the expense of other important requirements.

In a DC amplifier the FET prevents current from flowing through the phono cartridge, and different cartridge impedances won't affect offset. An FET's input impedance is very constant with frequency. Since this impedance is more linear than that achieved with a bipolar, it provides superior RFI without elaborate input filtering; a couple of ferrite beads on the gate are usually all that is necessary.

Of more concern than THD is harmonic structure. There seems to be some evidence that FETs produce smaller amounts of harmonic distortion than do voltage driven junction transistors, and that these harmonics decay more rapidly with increasing order. If the collector (or drain) currents are equal, low order even harmonics are virtually eliminated[1]. With bipolars, analysis shows that harmonic distortion is independent of the V_{BE} match. Matched collector currents, however, are essential for obtaining the lowest distortion. Monolithic matched pairs help ensure equal collector currents, as does the mirror current loaded differential.

The topology is differential with single-ended push-pull with output diode biased. The AC signal can modulate this bias string, which also represents significant impedance; we therefore bypass it with a high quality capacitor. Many amplifiers' bias networks are insufficiently bypassed; for example, simply placing a large capacitor across the bias transistor Q_5 will greatly improve Leach's "Low TIM Amplifier" (see *Audio* magazine, Feb. 1977, p. 30).

The single-ended push-pull output stage provides some loading of the preceding differential stage, thereby slightly reducing open loop gain; but this is of less concern in a passive RIAA design.

An output or line amplifier can be of the same configuration as a phono stage with the gain setting feedback resistor reduced to 15kΩ (x10 or 20dB). But I decided to try another circuit here. Since this line amplifier will deal with higher voltage swings, I used a large amount of local feedback in conjunction with negative feedback and derived the circuit from a single-ended compound-complementary amplifier (see *Fig. 4*) arranged in symmetrical push-pull (see *Fig. 5*).

A large amount of interaction and coupling occurs by using low impedance, high current design. This produces a very linear wideband width amplifier. My original design used different output transister types that ran at 23mA idle current. And a slightly different bias method was us-

Continued on page 22

THE MARSH PREAMP: PART I

Continued from page 20

ed but the topology was the same. Using an H-P 339A, THD at 20kHz and at 8 volts RMS (22 volts peak-to-peak) was .005%! Square-wave rise time was something better than 50nanoSec. Yet the circuit was rock stable. This was accomplished with only 15dB of over-all negative feedback. Unfortunately, the discrete circuit required heroic AC and DC matching which I feel would be beyond the resources of many audiophiles to duplicate.

As a practical matter of writing a construction article, I opted for the quad complementary pair DIP from Motorola, the MPQ6600A-2. I specified the high-gain (-A version) with their tightest matching (-2 version). With the reduced idling current (due to package dissipation limitations) and not as good complementary matching, the distortion is higher and bandwidth is reduced. Can you live with -3dB at 600kHz and less than .01% THD at 2 volts RMS at 20kHz?

BANDWIDTH ISSUES

Sonic performance noticeably improves with extended bandwidth at the top end. Recent tests indicate that under certain conditions one can hear a 10 degree phase shift.[10] To exceed the 10 degree requirement, even at the highest audible frequencies, we need a low distortion bandwidth greater than 250kHz; both line and phono amplifiers exceed this.

All the amplifiers are non-inverting. Psychoacoustic tests showed long ago that our eardrums are more sensitive to rarefaction (negative pressure or sucking outward) than to compression. In certain music an inverted signal can be quite noticeable. Conditioning also plays a part. For example, all the components of a live drum set (kick, upper and lower tom, snare, hi-hat, crash cymbals) when initially struck present a compression wavefront to the listener. Unfortunately confusion set in and the polarity question was shunted aside and eventually ignored as multi-microphone, multi-channel equipment became popular.

FIG. 5

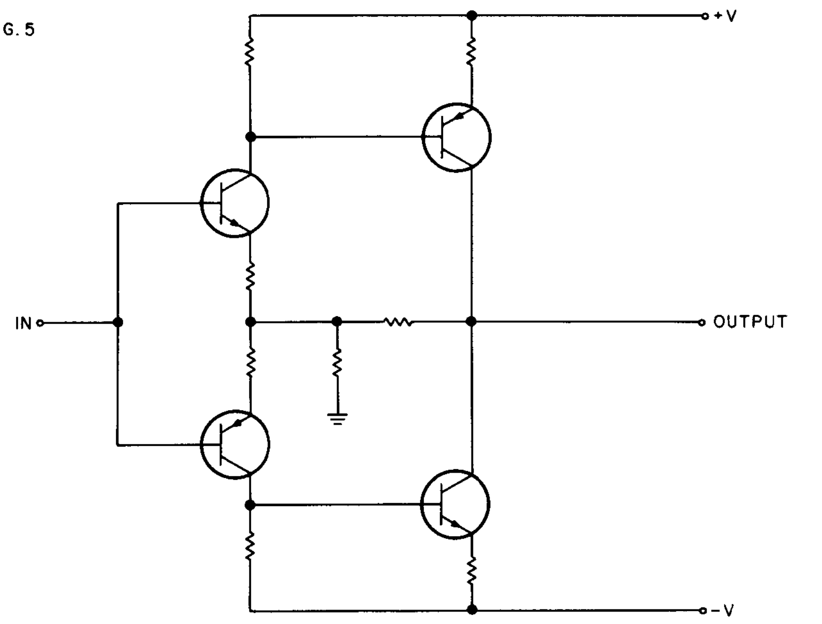


FIG. 6

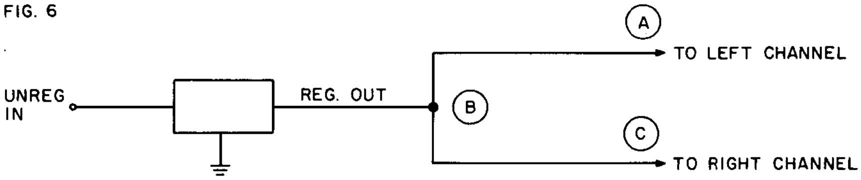


Fig. 5. Symmetrical push-pull, compound-complimentary amplifier.
Fig. 6. Single supply for stereo amplifier. Point B must have very low Z to prevent interaction of left and right channel.

I believe much of the confusion as to whether or not an inverted signal is a problem results from the use of multiple microphones. Recording engineers often use microphones (usually too many) on the performers' side of some instruments and on the listeners' side of others—sometimes they'll have mikes at both ends of a drum set. Then they mix the whole lot down together. Now, you play it back and try to decide which way is correct by switching your speaker wires' polarity; are you confused? Or have you been misled into believing polarity is not detectable?

Polarity reversal is easier to detect with the use of high energy transients. Piano recordings make a good test as they are fairly consistent in technique.

POWER PROBLEMS

The power supply, grounding, and decoupling are neglected design areas; most designers seem to be mainly, or solely, concerned with static hum and noise measurements. Yet proper power supply design can produce profound sonic changes. The supply must be very quiet and regulated against AC line variations and signal load demands; we can partially fulfill these requirements with a three-terminal regulator IC.

A Class A preamp's current demands are more constant than those of an AB or other design, so regulation requirements aren't particularly severe. However, if we have a single regulated supply feeding both left and right channels, we may get crosstalk between the sides—see *Fig. 6*.

Any signal on the left channel (A) will pass through B to C. But if point B had 0Ω impedance, then crosstalk via the supply rails would be no problem. We can hang a ton (or more) of capacitance to ground at B, but this capacitor is bulky, costly, and slow. Placing one high quality capacitor across the large one and another at the circuit boards helps us overcome the large polar capacitor's slow response.

Even if we had two separate supplies we would still need the high quality bypass capacitor, because at frequencies above a few kHz the regulator and large polar capacitor impedance increases; in addition, this capacitor is better able to sink signals than is the series pass regulator. Maybe a shunt regulator or a push-pull output drive regulation scheme would be beneficial. Much research remains to be done on the audible effects of power supplies.

CROSSTALK, PHASE

No matter what its origin, we must keep crosstalk to an absolute minimum; it causes image blurring and loss of detail, and alters spatial perspective. We can effectively reduce supply crosstalk by using separate regulator chips for each phono and line stage, locating each chip on the board near the stage it feeds; this solution is cheaper and less bulky than using huge aluminum capacitors. Locating the regulator within 2-3" of the circuit will also aid in keeping the supply line impedance low at high frequencies by minimizing lead inductance. We must also shield all signal carrying wires and put a grounded divider shield between selector switch channels if sections are close to one another. Reducing separation at 20kHz isn't too difficult.

Out of phase signals in music when combined cause a loss of information and reduce the sound field's width and depth. The effect of crosstalk or poor separation is to make stereo signals sound monophonic.

I could elaborate upon this subject at much greater length. I hope that instead readers will concentrate on some of the points I've touched on and come up with ideas of their own for improving my design.

A LOW DISTORTION GROUNDING SYSTEM

CIRCUITS ARE USUALLY THOUGHT OF as three terminal designs. The plus and minus inputs and the output. Actually, they are missing consideration of the fourth terminal. The ground.

A large percentage of system degradation can be traced to improper power distribution and/or ground loops. The symptoms of these poor designs are excessive noise, voltage spikes, and ringing on the power buses, crosstalk, AC power line noise pick-up, and poor load regulation, to mention a few.

Grounding, to be truly effective, must be returned to a single point. This is quite effective in reducing current loops but care is still needed in how the order of grounds for power supply and signals are applied. I suggest a separate ground buss for signal common and power supply common. Both buses being returned to a single point "star" ground.

The series impedance of a common ground line will cause voltages to be developed that are combined with the signal. Supply rail bypass capacitors on a single common ground area source of unwanted garbage (audio, ringing, noise, etc.). Using separate ground returns, and short conductors results in cleaner and quieter sounding amplifiers.

The characteristic impedance of the DC power distribution and ground line can be used as a figure of merit for comparing the noise performance of various power distribution transmission systems. For best noise performance, we want a power transmission line with a characteristic impedance which is as low as possible typically a few ohms or less. Therefore, the line should have high capacitance and low inductance.

Transient noise voltages in the power distribution circuit (which includes grounds) are produced by sudden changes in the current demand of the load. If the current change is assumed to be instantaneous, the magnitude of the resulting voltage change is a function of the characteristic impedance (Z_o) of the line:

$$Z_o = \sqrt{\frac{L_T}{C_T}}$$

The instantaneous voltage change ΔV_L across the load will then be $\Delta V_L = \Delta I_L Z_O$. The assumption of an instantaneous change in current is realistic for digital circuits, but not necessarily so for analog circuits. However, even in the case of analog circuits Z_O can be used as an indicator of noise performance.

I've read many times that a large gauge wire should be used to assure a low Z ground. There seems to be an overemphasis with design procedures that are based on DC parameters. It is impedance in an AC cir-

EQUALIZER COMPONENTS—ONE CHANNEL

RESISTORS (connect in series)

27k	=	909Ω + 26.1k ± 1% metal film (MF)
3.93k	=	3.83k + 100Ω ± 1% MF

CAPACITORS (connect in parallel)

0.081μF	=	.047μF + .033μF polystyrene
0.02778μF	=	.022μF + .0047μF + 500pF polystyrene

FIG. 7

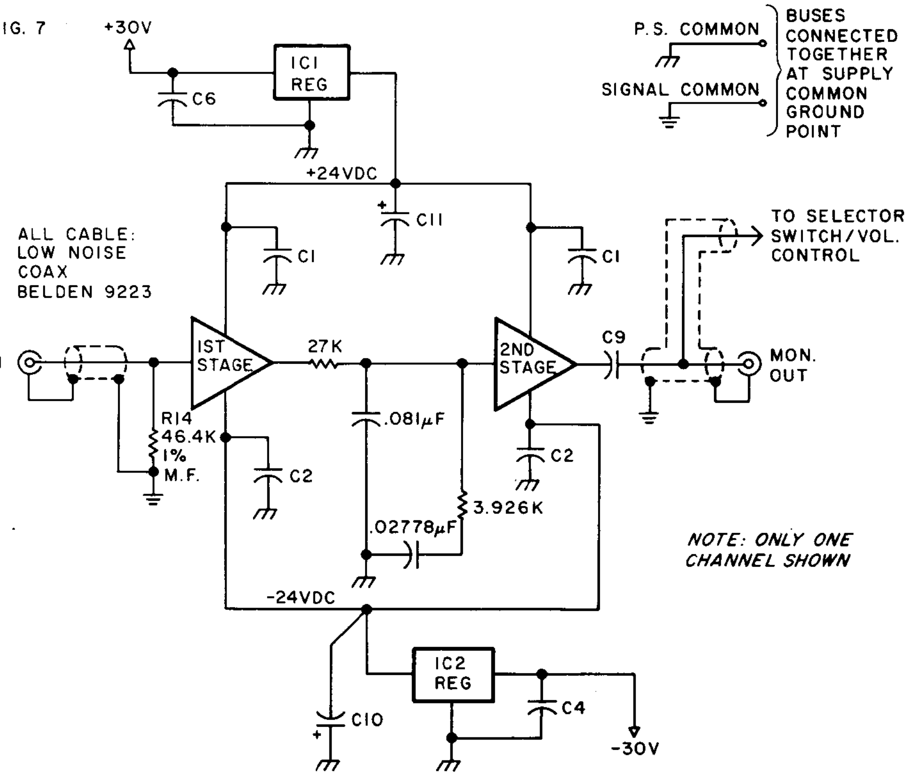


Fig. 7. Block diagram, input and equalization components of the passively equalized preamp stage. See Fig. 9 for details of stages 1 and 2.

FIG. 8

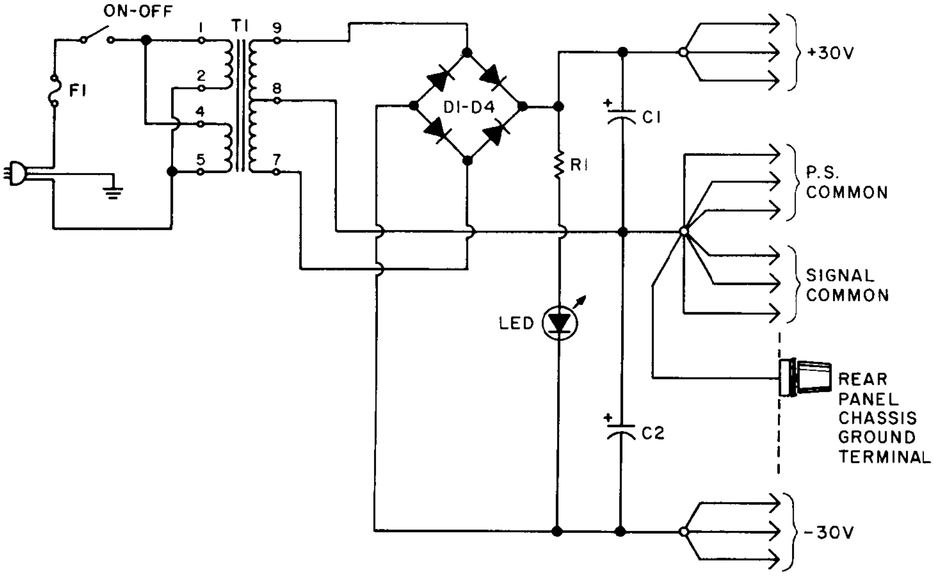
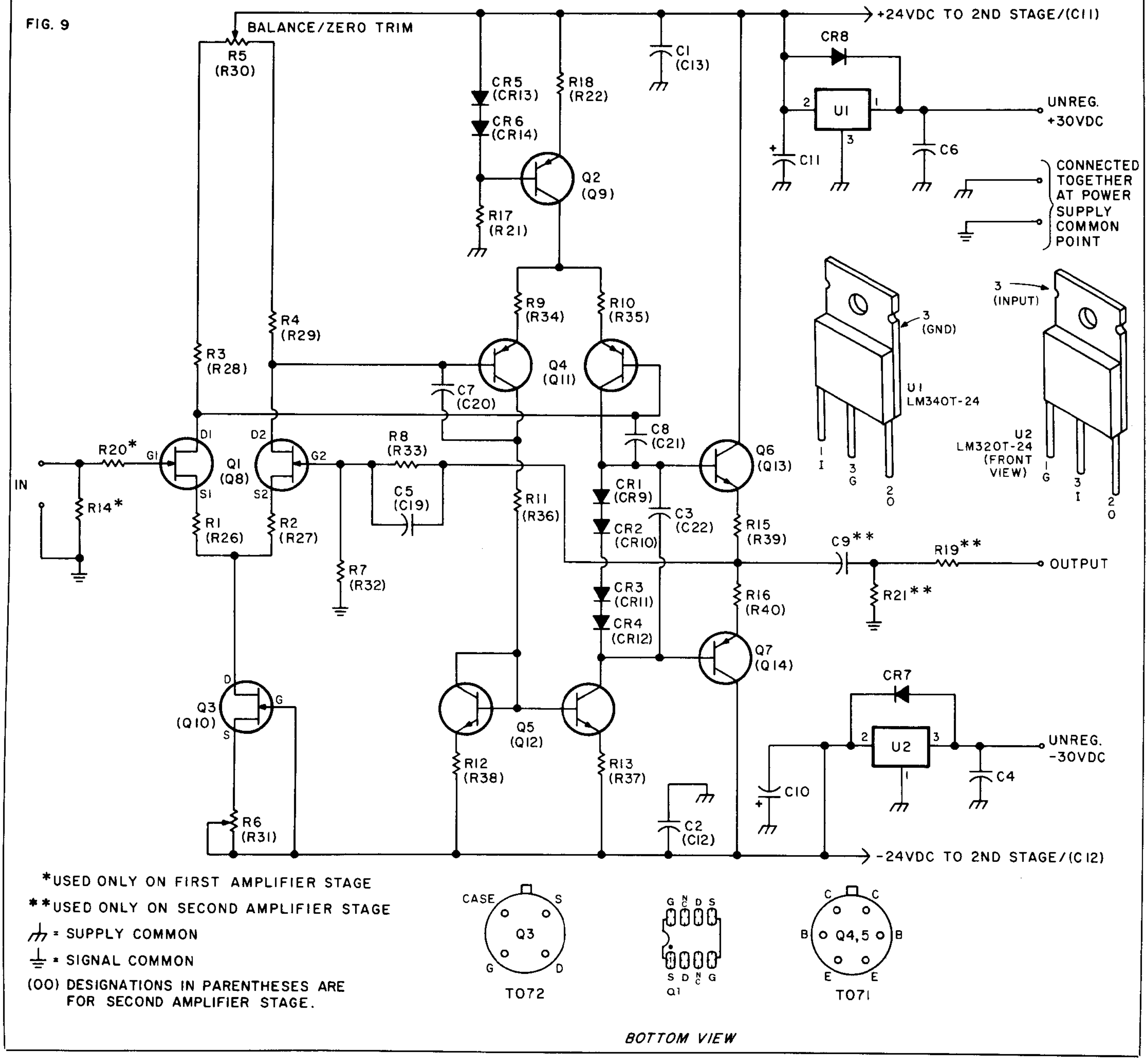


Fig. 8. Power supply circuitry.

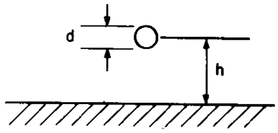
Fig. 9. Phono stage amplifiers. Designations in parentheses are second stage components. See Fig. 7.

FIG. 9



cuit that we are dealing with (just a reminder). A large gauge conductor isn't very effective in itself in lowering Z.

Suppose we use a wire of .148″ diameter ($\approx$ #14 gauge), and that this wire is a ¼″ from the chassis thus:



$$Z = \frac{60}{\sqrt{\epsilon_r}} \cosh^{-1}\left[\frac{2h}{d}\right]$$

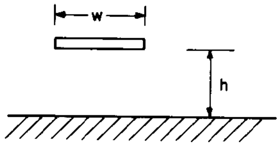
for $2h/d \geq 3$, $$Z = \frac{60}{\sqrt{\epsilon_r}} \ln\left[\frac{4h}{d}\right]$$

where $\epsilon_r = 1$ for air

$$Z_o = 60 \ln\left[\frac{1}{.148}\right] = 115\Omega$$

This amount will nullify the work put into a power supply which measures Z of milliohms at the supply terminals (but not at the circuit).

The inductance can be reduced by using a rectangular cross section conductor (now L) instead of a round conductor and by having two conductors as close together as possible (high C) thus:



For $W \gg h$, $$Z_o = \frac{377}{\sqrt{\epsilon_r}}\left[\frac{h}{w}\right]$$

If we use a flattened braid ⅜″ wide and separated by a thin (.005″) sheet of mylar, the characteristic impedance is:

$$Z_o = \frac{377}{\sqrt{5}}\left[\frac{.005}{.375}\right] = 2.25\Omega$$

Since employing this method, I've persuaded others to try it in their commercial equipment and personal designs. The sonic improvement was most noticeable in providing a more stable image, and greater clarity. W. Jung reported similar improvement to his highly modified PAT-5 after changing his ground to a truly low Z one. Of course, this works quite well with power amplifiers too.

CONSTRUCTION

Construction is really quite straightforward. I used vector perf board for my prototype's circuitry; it looked rather messy compared to a printed circuit board but worked every bit as well.

I chose not to include complex input switching arrangements for many sources, preferring to use outboard patch panels if necessary. This keeps to a minimum the number of contacts which the music must pass. If you don't want to be as spartan and build some flexibility into your preamplifier, use silver or gold contacts in your switches. I prefer silver because it has the lowest contact resistance. It oxidizes easily so these switches must be of the multiple finger, self-cleaning wiping action type and be fully enclosed or sealed. These are expensive and hard to find.

Perhaps more practical are the gold contacts which are easy to come by in all manner of styles and configurations. Use only gold RCA jacks and plugs for all input and output as well as on cables. I eliminated the output jacks entirely by removing the plugs from one end of a pair of Gold Ends cables and hardwired them directly to the line amplifier output. I brought the cables out of the chassis through rubber grommets and used cable ties on the inside for strain relief.

One switch contact by itself is bare-

POWER SUPPLY PARTS—TWO CHANNELS

R_1	4.3k, ±10%, 1W
C_1, C_2	4,000µF/50V electrolytic, computer grade
D_1, D_4	IN4003 or one WO2M bridge. 1.5A/200V rating.
F_1	½A, SloBlo
S_1	SPST
LED	Litronix RL4850 or equiv. (James XC556R)
T_1	Signal DP-241-6-56; 56VCT @ 0.54A

PARTS LIST: PHONO PREAMP—ONE CHANNEL

RESISTORS

R_1,R_2,(R_{26}),(R_{27})	100Ω
R_3,R_4,(R_{28}),(R_{29})	14.7k, ½W
R_5, (R_{30})	1kΩ trimpot, CTS350 or IRC100 series
R_6 (R_{31})	2kΩ trimpot, CTS350 or IRC100 series
R_7 (R_{21})	1.47k
R_8 (R_{33})	31.6k
R_9,R_{10},(R_{34})(R_{35})	511Ω
R_{11} (R_{36})	6.81k
R_{12},R_{13},(R_{38})(R_{37})	5.11k
R_{14}	46.4k
R_{15},R_{16},(R_{39})(R_{40})	46.4Ω, ½W
R_{17} (R_{21})	10k
R_{18} (R_{22})	162Ω
R_{19}, R_{20}	100Ω
R_{21}	100k

All resistors metal film, ±1%, ¼W unless specified otherwise.
Volume control 10k Allen Bradley type JJU.

SEMICONDUCTORS

Q_1 (Q_8)	2N5564 (National) 8 pin minidip
Q_2 (Q_9)	2N2907A
Q_3 (Q_{10})	2N3823 (Texas Inst.) TO72
Q_4 (Q_{11})	AD821 (Analog Dev.) TO71
Q_5 (Q_{12})	AD811 (Analog Dev.) TO71
Q_6 (Q_{13})	2N2219A
Q_7 (Q_{14})	2N2905A
U_1	LM340T-24
U_2	LM320T-24
CR_1,(CR_9),CR_2(CR_{10})	
CR_3,(CR_{11})CR_4(CR_{12})	
CR_5,(CR_{13})CR_6(CR_{14})	IN4148
CR_7, CR_8	IN4003

HEATSINKS

U_1, U_2 Thermalloy 61078-14, or 6030, or equivalent.
Q_6 (Q_{13}), Q_7 (Q_{14}) Thermalloy 2275R or equivalent.

CAPACITORS

C_1(C_{13})C_2(C_{12})C_4,C_6	5µF/50V metallized polycarbonate (Elpac or Wesco), low inductance mylar®
C_3. (C_{22}), C_9	10µF/50V metallized polycarbonate (5-10µF metallized polypropylene would be better for C_9 but is expensive.)
C_5, (C_{19})	5pF ±5% polystyrene or silver mica
C_7, (C_{20}), C_8, (C_{21})	10pF ±5% polystyrene or silver mica
C_{10}, C_{11}	470µF/50V electrolytic, low loss Panasonic LS series type ECE B1HV471S of Sprague 673D

MISCELLANEOUS

Shielded Cable Belden 9223 low noise coax; 9452; RG-58C

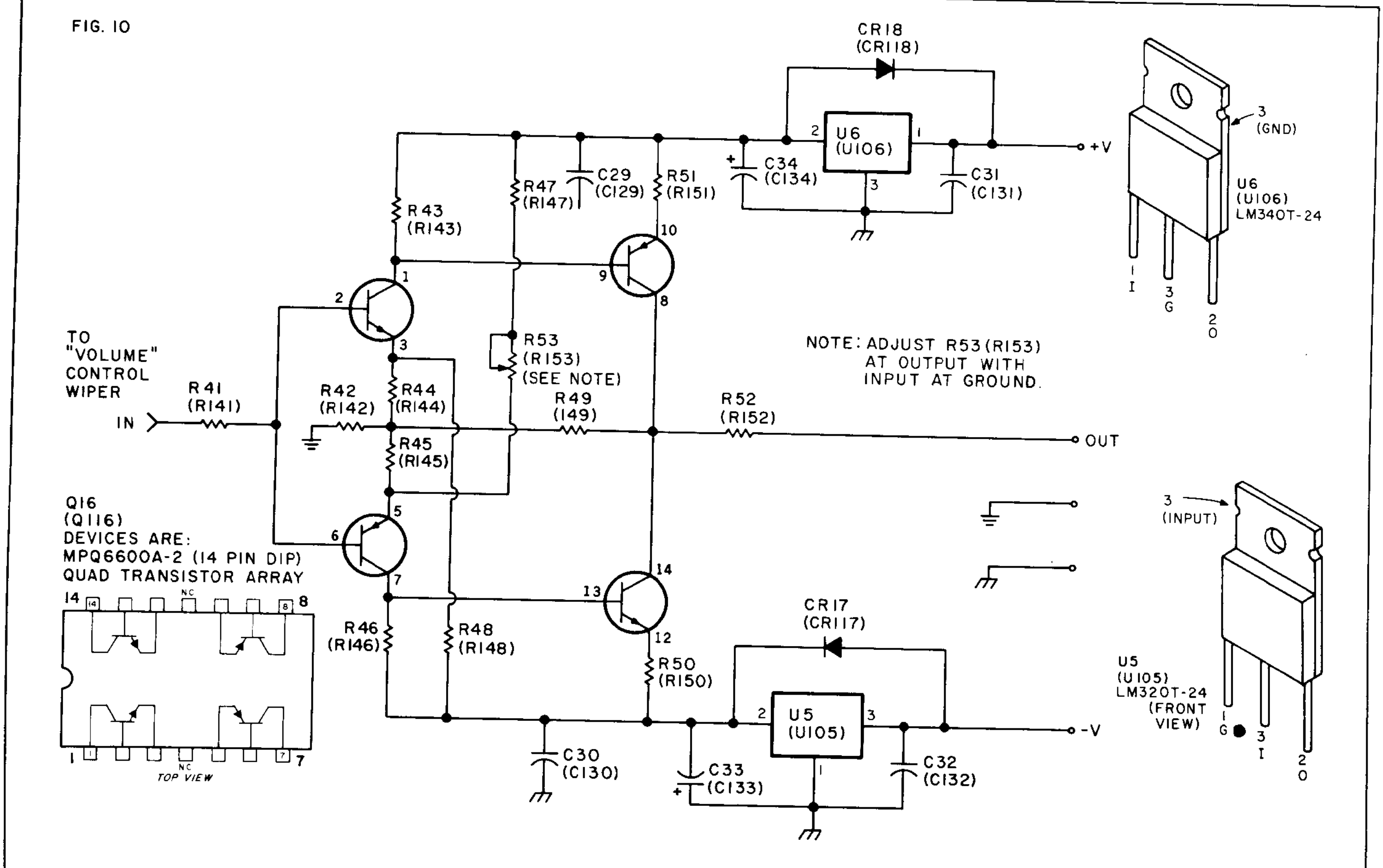


Fig. 10. High level output amplifier. Parts designations in parentheses are for second channel.

PARTS LIST: HIGH LEVEL AMPLIFIERS—TWO CHANNELS

RESISTORS

R_{41}, R_{141}, R_{42}, R_{142}, R_{44}, R_{144}, R_{45}, R_{145}, R_{52}, R_{152}	100Ω
R_{43}, R_{143}, R_{46}, R_{146}, R_{49}, R_{149}	1kΩ
R_{47}, R_{147}	1.47k
R_{48}, R_{148}	2.15k, ½W
R_{50}, R_{150}, R_{51}, R_{151}	383Ω
All resistors metal film, ±1%,	¼W unless specified otherwise.
R_{53}, R_{153}	1k trimpot, CTS series 350 or IRC series 100

CAPACITORS

C_9, C_{129}, C_{30}, C_{130}	10μF/50V metallized polycarbonate (Elpac or Wesco 32MPC)
C_{31}, C_{131}, C_{32}, C_{132}	5μF/50V metallized polycarbonate (Elpac or Wesco 32MPC)
C_{33}, C_{133}, C_{34}, C_{134}	470μF/50V low loss electrolytic Panasonic Z series type ECE B1HV471S; Sprague 673D.

SEMICONDUCTORS

U_5, U_{105}	LM320T-24/w heatsinks (*see Fig. 10*)
U_6, U_{106}	LM340T-24/w heatsinks
Q_{16}, Q_{116}	MPQ6600A-2 16 pin dip Motorola
CR_{17}, CR_{117}, CR_{18}, CR_{118}	IN4003

TESTS FOR THE RESULT

"A lot of things can happen to a 24-track master between original recording in London, sweetening in New York, and cutting the lacquer in California. Some of them will happen no matter what you do." So begins an ad for a famous noise reduction system. There certainly are a lot of steps between studio(s) and your recordings. Each adds not only noise but distortion. Then it must contend with your turntable/arm/cartridge and perhaps a pre-preamp. All this obscures the original and interferes with my ability to judge the performance of a preamplifier, power amplifier or loudspeaker.

For evaluating a preamplifier, I produce my own master tapes and play them through an inverse RIAA network (suitably attenuated) [see TAA *1/80, pp. 22-24] fed to the preamp phono input. The advantage is of course much higher fidelity going into the preamplifier. But just as important, you were there when the recording was made and know what the original (live) music sounded like. This is a tremendous advantage when judging the sonic and spatial characteristics of the preamplifier or power amp. Although I used the Otari MX5050-8D (8 channel deck) when I was doing mobile recording with excellent results, I find the 15 ips, ½ track Revox A77 and two microphones to be very satisfactory, and highly recommend Ed Long's Pressure Zone Microphone technique. [db magazine, Jan. 1980, p. 31-32, and* High Fidelity, *Aug. 1978, pp. 60-63.]*

ly detectable, but it becomes more noticeable when we eliminated several contacts from the signal path. Periodically, clean all the system cable plugs and chassis jacks inside and out with alcohol and be sure all fit tightly.

The power transformer is in the right corner near the power on-off switch, boxed in by an aluminum two-sided wall. Nearby are the rectifier and filter capacitors; another divider runs from the front to the rear panel, separating the power supply circuitry from the amplifier circuits. A hole near the divider bottom allows the supply lines and grounds to exit.

WIRE AND WIRING

Although conductors are not normally considered components, they do have characteristics important to electronic circuits' noise and transient performance. Among the most important is inductance: even at low frequencies, a conductor may have more inductive reactance than resistance.

For low impedance grounds, use flattened braid enclosed in shrink tubing and taped down against the chassis bottom. Supply wiring should be #18 or larger; place it away from amplifier circuitry.

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Rather than daisy-chain the supply lines and grounds from one board to another, I wired each stage (left, right, phono, and line) separately to the single point of the filter capacitor (+) or (−) and to the single-point ground. The signal common also returns to this same single point ground terminal via a separate wire.

SETTING UP

A few adjustments require a DC voltmeter able to see less than 10 millivolts. Center all trim pots and turn on the power—of course you've first double checked the wiring and polarity of all caps, diodes, and transistors. If supply voltages are OK, let the preamplifier stabilize for about five minutes.

First, adjust the current source pot of the FET differential input (R_6) for a voltage drop across either drain resistor (R_3 or R_4) of 12 volts. Then adjust the "balance" trim pot (R_5) for zero volts (no greater than 5mV) at the first phono amplifier stage output. Short this output to ground with a short jumper wire and proceed to adjust the second phono amplifier stage's current and balance. The DC voltage at the second stage's output (overall phono preamplifier output)

Continued on page 58

FIG. 11

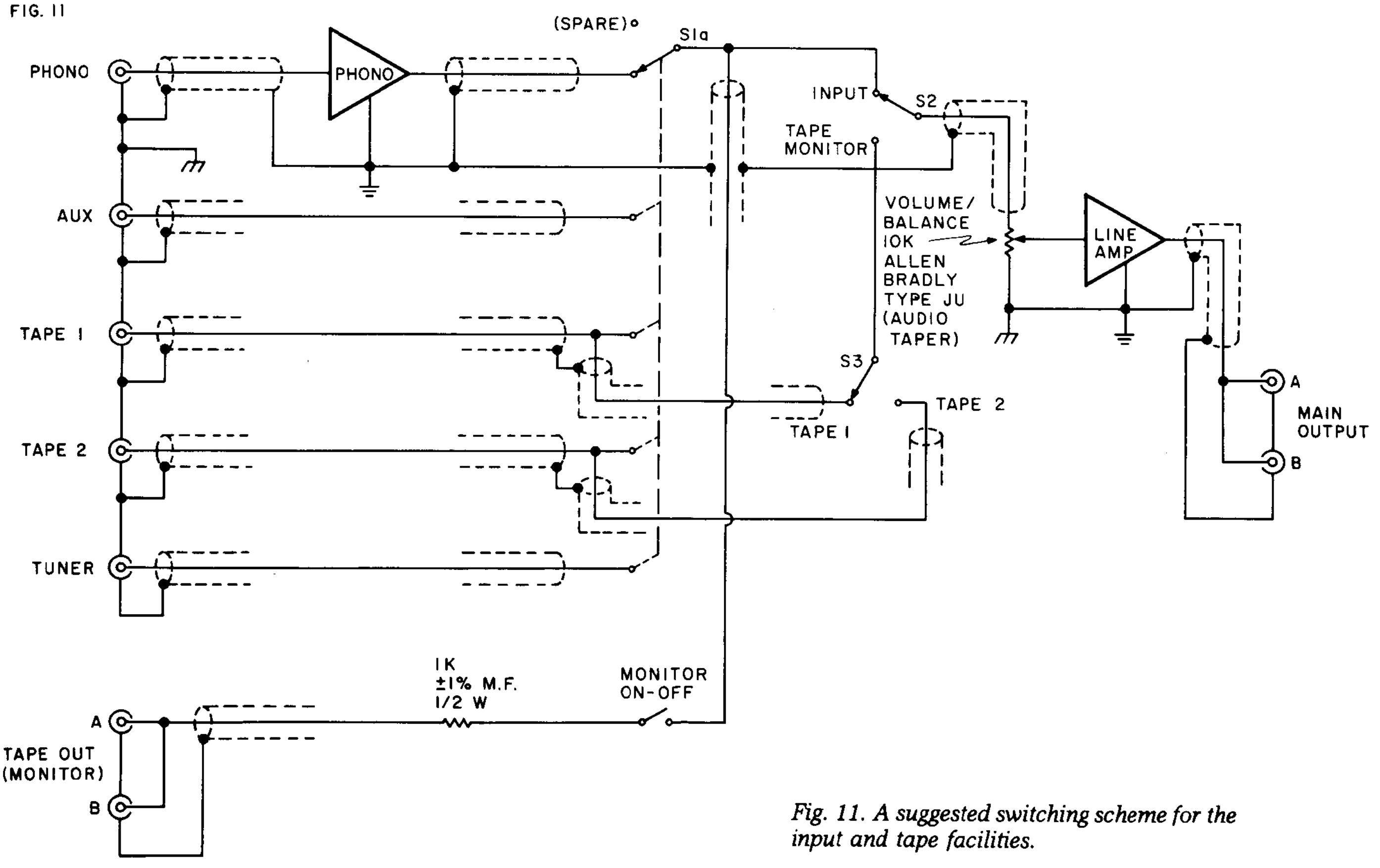

Fig. 11. A suggested switching scheme for the input and tape facilities.

we need more inquiry and open communication to resolve and explain our different observations. Value judgments as to importance, practicality, expense, etc., should be left to individual decision; they do not belong in the process of research.

As Curl, Moncrieff, and others have noticed, even ceramic and tantalum bypass capacitors on the power supply rails introduce audible sonic degradation compared to film capacitors as bypass caps. I've heard the differences too. I don't believe it takes "Golden Ears" to hear the effects of poor contacts, capacitors, or whatever, although it does often take an experienced listener. I, for example, cannot hear a poor switch contact on average gear, but I can on the very best equipment. A typical set-up will have many contacts in the signal path. The best equipment makes the differences clearer, sometimes subtle perhaps but nevertheless audible, even with double blind tests.

DICK MARSH
Livermore, CA 94550

I deeply regret that a large number of excellent letters on the Lipshitz/Jung forum could not be used in this issue for lack of space.—Ed.

THE MARSH PREAMP: PART I

Continued from page 27

should be within 10mV with the jumper removed.

Make these adjustments with the input shorted. You may have to go back and retrim them after a long warmup period. Over several days the monitored phono DC offset drifted less than ±10mV. I've decided to let my preamp stay on all the time. These procedures will give you under 0.01% THD.

The line amplifier adjustment is to provide zero volts DC at the line output. Adjust R_{13} for zero volts ±5mV or better. I used fingernail polish to set and keep each adjustment fixed.

A potential problem with a DC-coupled phono preamplifier comes when you use pre-preamps with leaky output coupling capacitors. The leakage current will develop a small DC voltage at the preamp input. When this is amplified the resulting imbalance leads to increased distortion. If your DC offset increased when you connected your pre-preamp, then you'll have to replace those output capacitors. I've tried several different pre-preamps without problems.

Be sure you have excellent solder joints. One microampere through 4 milliohms = 4 nanovolts, equal to the noise of a 1000Ω resistor. I recommend silver bearing solder (2-3%).

Circuitry reduced to a schematic

and parts list can be deceptively simple. An amplifier's success depends largely on its components and construction techniques. Although this design is more complex than IC designs and active RIAA circuits, I feel the effort is well worth it; I think you will agree. □

Etched circuit boards for this project are in preparation and will be published in issue 4, 1980. — EDITOR

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