HEATH UPGRADE

Many *aX* readers were more than a little confused after reading Bruce Brown's "Upgrading Heath's W6 Power Amp" in the March issue. The schematic accompanying the article is for the Heathkit W5, as many of our eagle-eyed readers pointed out. We regret the error and are publishing schematics for the 6M and A versions on our web page, www.audioXpress.com.—Eds.

Bruce Brown said the plate voltage on the 6550s will exceed 500V or even go as high as 550V before the tubes warm up. In the first trial of the rebuild, he added a choke that lowered the plate voltage by 35V, but said it affected the bias meter reading. Then he said he removed the choke and still managed to keep the plate voltage at a reasonable 452V. How did he manage to do this? There is no mention of any other changes except removing the choke.

Cal Jonstone
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Bruce Brown responds:

Regarding the plate voltage before and after choke addition, many older tube amps were designed to run off 110V AC. With typical line voltage today—up to 127V—there is the potential to run very high voltages in these rebuilt amps. This can be a problem for both the filter caps and the tubes used in these amps.

The W6 doesn't have a problem with the cap voltages because it actually series-connects two filter caps to provide a rating well above what they will ever see. The Heathkit manual specifies 460V on the plates of the 6550s. This is ±20%. If you are providing over 500V on the plates of the 6550s, you will probably shorten the tube life, unless you are using NOS (read expensive) tubes.

The idea of the choke was to lower the anticipated high plate voltage below 500V. It did work, but because the meter in the 6 actually reads current draw and this would be affected by the voltage, it caused the meter to not read at the indicated point. When I removed the choke, the plate voltages were actually within specs, and the meter read correctly.

The thermistor I used was from Electronic Goldmine (www.goldmine-elec.com). They have a resistance cold of 6.5Ω and as it warms up it moves toward 0Ω. It is rated at 6.5A and the part number is G12789 and are 4 for $1.

Mr. Brown has an apparent misunderstanding of the way the bias meter works on the W6M. He seems to think that the key spec in bias setting is the –50V on the 6550 grid(s). This is a Nominal specification; i.e., if all is as the amp was designed, there should be about that voltage on the grid when the meter indicates proper bias. This should, obviously, vary with the parameters of the individual tubes used, and will be different for unmatched tubes.

After digging up a W6M schematic on the Internet, I confirmed my suspicions. The meter is an Ammeter, in series with each tube/winding (depending on switch position, of course). If you wish to properly bias this amp, you *must* use the ammeter reading; the voltage reading is irrelevant. If the meter reading is correct, ignore the voltage reading!

You normally set bias on 6550s for an idle current of 40–60mA per tube. Of course, if the meter is damaged or your amp has no meter, and the 50V reading is the only way you know to set the bias, what choice do you have?

Well, actually, you have a very good other choice. With the amplifier completely cold, check that its power supply is totally discharged, then measure the resistance of each tube's transformer winding.

Assume each side measures 100Ω for this example, and that you wish to bias our 6550s at 50mA. Allow the amp to warm up about 20 minutes with minimum bias, then measure the DC voltage across the winding. Use ohm's law, E = IR; since R = 100Ω and you want an I of .05A, you would adjust the bias controls until there was 5V (100 × .05) across each side of each winding. Voila! Perfectly biased at 50mA per tube.

Alan Rauchwerger
Rochelle Park, N.J.

Bruce Brown responds:
It is correct that the meter reads the current through the output winding; unfortunately, many times these meters are inaccurate or not functioning. The Heath assembly manual does list the correct voltages and does specify that the bias voltage is −50V, when the amp is set up and operating correctly. Alas I am not an engineer, just a hobbyist who doesn't mind the terrific amount of work involved in trying to help others by writing a do-it-yourself article. My suggestion would be to spend the time writing an article for *audioXpress*, since it is the subscribers who contribute articles that keep this great hobbyist magazine interesting.

LOW NOISE

This is in response to David Hadaway's letter (*aX* 3/06) concerning my Noise Meter Amp article. He was quite correct in his explanation of the input noise degradation with low value resistors. I originally built the project to amplify low-level AC noise for the DaCT CT102 low-noise power supply review (*aX* 10/02), where the impedances were hopefully very low. Then I expanded the use for more general AC noise measurements by adding the input impedance switch and R24.

On reflection, I should have made R24 larger, as Mr. Hadaway suggests, since R2/R24 is in shunt with Zout of the source. I chose 7.87k to avoid a larger value for C11. I wanted a 4Hz LF –3dB to ensure flat response at 20Hz.

As far as the selection of the AD745, it is among the leaders in low noise for a FET input IC. Walt Jung also pointed out that a FET input op amp can be directly coupled—i.e., no AC decoupling is required around R6 and R7, with no possibility of meter-pinning transients when the gain range is switched.

As to the AD745 compensation, the high frequency noise gain of the U1/U2 stages is 5×, as set by the capacitors (discussed in the article). As long as a bandwidth limiting feedback cap C14 (or

C18) is used across R5 (or R10), then the C12, C13 (or C17, C18) compensation will be necessary.

The AD745 is now "semi-available" (I found some of the DIP versions at Rochester Electronics, but their minimum order is $100). The LT1792CN8 is the closest FET part to the AD745 that LTC lists, but it has lower performance. Alternatively, Walt suggested that a bipolar input op amp such as the AD797 or the LT1115 would lower the voltage noise considerably, at the expense of higher current noise and potential biasing complications. The LT1126CN8 is functionally equal to two AD745s, and is currently available in a DIP package from Digi-Key. ADI parts are available from Newark Electronics.

Yes, surely you can do better with a custom-design discrete circuit, but an IC does have the advantage of drop-in design simplicity. I am quite interested in the simpler three-transistor circuit that Mr. Hadaway mentions in his letter. Some *aX* readers might find it useful as well. Perhaps Mr. Hadaway could provide a detailed schematic in a follow-up letter that provides the same function as in my article. A 14dB S/N improvement would be a great thing to have for this type of application.

Chuck Hansen
Ocean, N.J.

TRANSFORMER POWER GAIN

I just finished reading "Loading Step-Up Transformers for MC Cartridges" by Cornelius Morton in the March '06 issue. While I have no MC loading issues myself, I appreciate seeing any article regarding improvement of LP playback. I must, however, take exception to his references to the power gain of transformers. I remember learning in high school electronics class (and checked reference books to reconfirm my ailing memory) that probably the most basic rule of an ideal two-winding transformer is E1 × I1 = E2 × I2, i.e., the power in the primary equals the power in the secondary. Thus, the power gain of any transformer is 0dB (or less in the real world).

Further reading and study of the article and calculations revealed that, apparently, Mr. Morton was using the fact that the power ratio for a voltage gain P (in dB) equals the square of the voltage ratio for a voltage gain of P (in dB) as a shortcut to deriving the impedance ratio. This should have been made clear in the article.

Around 1976, I went to see Harvey Rosenberg and his staff at "Tube God." I talked to them about more mods to my Audio Research SP-3A1 preamp; they advised me to bypass its phono1/phono2 switch, which switches the inputs at cartridge-level. I did this as soon as I got home, and it turned out to be the most effective mod I ever did to the preamp, because the fewer contacts at cartridge level, the better.

Thus, potential users of Mr. Morton's calculations would be better served by calculating the proper resistance value and soldering the resistors across the 47k input resistors. If the resistors are to be changed often, solder component jacks across the 47k resistors. Either way, you will have fewer contacts in series with your cartridge. It's more trouble than Mr. Morton's method, but very worthwhile in sound quality.

Alan Rauchwerger
Rochelle Park, N.J.

Cornelius Morton responds:

Thank you for your interest. Actually, I thought that I had taken care of the dB/power problem in the third paragraph of the Rest Of The Story section: "When you take the voltage gain across the same impedance—in this case the preamp output—the power gain is equal to the square of the voltage gain." In actual practice gain in dB may be expressed as either 10×Log (power out/power in) or 20× Log (E out/E in), E in AC volts. For circuit analysis it is much more convenient to identify all gains in dB of voltage gain, as they are additive.

For example, 26dB + 34dB = 60dB versus 19.95 × 50.1 = 999.5 voltage gain, which when squared is approximately 10^6, or 60dB. A second reason is accuracy. Assume an MC cartridge with an output of 0.316mV when loaded with 100Ω and an amplifier chain providing 100W output into 8Ω when driven by the cartridge. Note that all voltages will be RMS. The power developed by the cartridge is $(0.316\text{mV})^2/100 = 1 \times 10^{-9}$W and the amplifier output is 10^2W; the difference is 10^{110}, or 110dB gain (power). The voltage output into 8Ω to develop 100W is 28.3V RMS.

The voltage gain is then 28.3/0.316mV = 89557 and the voltage gain is 20×log 89557, or 99dB. Seems there is an 11dB difference. Generally the circuit design requires a voltage gain goal, which is readily available from the voltage gains in dB but requires more work when using individual stage power gains. The 11dB difference is due to taking power readings across differing impedances and may be rectified by converting these differences into dB, in this case 10×log (8/100) = −11dB. Doing this for each stage is tiresome and prone to mistakes so using the voltage gains in dB is preferred.

As stated in the article, the gain of moving coil step-up transformers may be specified in turns ratio or dB and some manufacturers actually use both. For example:

Jensen JT-34K-DX, gain = 31dB, turns ratio = 1: 37.
Rothell, gain = 24dB.
Quicksilver Audio, gain = 23dB.
Ortofon T20 MKII, gain = 28dB.

Jensen specified both gain and turns ratio, the rest just gain, in dB, voltage gain as the power gain of the transformer only is slightly negative as you noted. And, yes, it is an easy way to find the impedance ratio as well as the turns ratio.

Your comments on soldering in the desired resistance are very valid. Contacts, especially low-level switch contacts, tend to oxidize with age; the current through low level switches is insufficient to clean the surfaces. In the design presented here, the connections to the f-m-f adaptors are on the high impedance side of the matching transformer where variations in the contact resistance are minimized. The cartridge to arm wiring and the table to step-up transformer connections are the ones in which contact resistance variations are real problems. There is an alternative if this does become a problem.

During World War II Dow Corning developed a silicon compound for the Army Air Force to eliminate high altitude corona discharge and arcing on aircraft ignition systems: Dow Corning 4, or DC 4 as it is commonly known. After the war the marine crowd loved it, as well as anyone trying to waterproof high voltage systems. In the '50s another aspect of DC 4 was found.

When a thin film of DC 4 was applied to a clean wiping contact, the contact resistance was reduced by 50 to 80%. This saved the mental stability of many early Dual owners, as the Dual arm headshell contacts were notorious for hum pickup and being just plain noisy. Dow Corning was never fully able to explain this behavior, though they did circulate several bulletins on the effect. DC 4 is still available at about $15 for a five-ounce tube and is very handy to eliminate noisy connector contacts.

MUSIC PEAKS

I extend my belated commendation to Dennis Colin for his fine article on music peak power in the November 2005 issue of *audioXpress*, and to Robert Cordell for his fine follow-up letter in the March 2006 issue. Both are very worthy contributions in an important subject area which is badly under-published.

They both report measurements on recorded music, which is what we must contend with in home playback. Colin finds a required peak power of 11 to 16dB above the "average" value from a meter with a 1.1 second time constant; Cordell finds 11 to 14dB above the Radio Shack meter on "slow" setting. These margins place serious demands on a playback system.

It is even more worrisome to consider earlier measurements on actual live music[1-3]. These were made with meters faster than the above for the perceived sound level against which the peak level is compared. (The Radio Shack "fast" setting corresponds to the ¼ second ear-related slow time constant considered by Fletcher.) Correlating these several earlier investigations yields a typical required margin for symphonic music of 13dB above the RS "fast" sound level values. I do not know by how much the RS "fast" level might exceed the RS "slow," but it must be at least several dB. The necessary margin above the "average" test levels reported by Dennis and Robert could exceed 20dB[2]. It thus seems that music peaks may have already been clipped in the recording process for many CDs, even well-regarded CDs.

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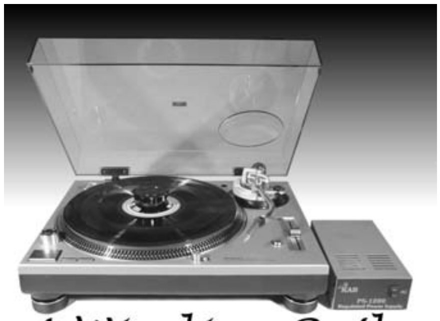

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Ed Poindexter
Chelsea, Mich.

TUBE TIP

High voltage variable lab type power supplies are difficult and expensive to build but necessary to aid in developing new tube circuits. While browsing eBay a few months ago, I stumbled across a source of constant voltage and/or constant current units that supply up to 200mA at 4000V DC for a very reasonable price. These are Electrophoresis power supplies used in biology labs.

These units are fully instrumented with meters or digital readouts for current and voltage. They all have just one variable voltage output, but they can be used for bias supplies, B+, or any number of other uses. I found several 1000V DC units for under $20, and the higher voltage first-class ones usually go for around $100. I picked up a Fisher 430 that has been instrumental helping me design an output using 211As. I have also found them useful for reforming high voltage electrolytic caps.

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AMP ABUSE

I enjoyed reading Jim Carlyle's article in February 2006 *aX* about using clamped bias in a Class AB2 vacuum tube amplifier (p. 6). Clamping the bias to mitigate the effects of rectification at the grid under over-drive conditions is a neat idea. We've all seen the effect he describes: if you look at the fixed grid bias as you increase drive level with a sine wave, it will remain fairly steady as you increase level until approximately the clipping point, where it will quickly begin to go negative. As long as this rectified charge stays on the coupling capacitors, the amplifier will be operating with too much negative bias at other points on the waveform, often leading to crossover distortion.

Here's my question, however. While a sinusoidal drive will push grid bias positive on a regular basis, music, on the other hand, with its significant peak-to-average ratio, should only rarely be clipping the amplifier, resulting in very little bias shift due to grid rectification. The average current produced by the low-duty-cycle grid current conduction with music should produce very little bias shift. In other words, it seems that this shouldn't be a problem unless you are pushing the amplifier so hard that it is clipping on a very regular basis, which, of course, is beyond the boundary of high fidelity. Has Jim solved a problem that really only exists on the test bench unless the amplifier is being abused?

Bob Cordell
Holmdel, NJ

Jim Carlyle responds:

Thank you for your carefully worded argument, which seems to me to be 100% correct. I apologize if it was not implicitly obvious that my invention is only useful to people who do abuse their tube amplifier.

Let's be clear now. A great deal of historic psychoacoustic research has proven that peak clipping on music can be as much as 2 to 6dB, depending on music type, without being noticeable to 95% of listeners. Radio transmitters and master analog tapes exploit this fact fully. But, in stark contrast, even decimal percentages of crossover distortion immediately sound harsh and crunchy to nearly everyone.

Let's also be clear that most tube amplifier owners would dearly love more dynamic headroom in their 10W or 20W or 50W amplifier. 1250W of tube power is available (e.g., VTL Wotans), but unaffordable ($27,000).

Finally, let's also be clear that solid-state amps do not have the RC tube amp problem of shifting into crossover distortion on overload. On the other hand, clipping them does spray ultrasonics, which can smoke your tweeters before you hear any overload.

I liken my dynamic bias clamp to the turbo on my car. It allows an economical power unit to perform several dB above itself on an occasional basis, such as for green-light launching. But I wouldn't tow a boat uphill with it. Nor would I blast sine waves through my stereo system, even though Magneplanar speakers are almost uncookable.

So Bob is correct. Sine-wave testing, like dynamometer testing, has its place, but does not mimic normal conditions of use. *aX*