



Upgrading Heath's W6 Power Amp

With these tips from a vintage audio enthusiast, you, too, can successfully tame the Behemoth.

By Bruce Brown, RPh.

In 1957, there were hundreds of tube amplifiers on the market. Heathkit had successfully launched many great amplifiers, including the widely successful, extremely quiet W5. (See *audioXpress*, Dec. 2004, for my rebuild article.)

Responding to “power push” popularity, Heath introduced the W-6M, which produced 70W RMS and 140W peak power, and was Heathkit’s most powerful tube amplifier. It was also the first Heathkit audio amplifier that used silicon diodes in a voltage doubler. This resulted in 470V delivered to the plates of the 6550 output tubes. These tubes had been rated for 600V, so the conservative use in these amplifiers assured a long, trouble-free life. But the unit was plagued by stability issues, which I address in this article.

The design of the circuit is different from earlier Heathkit amplifiers, and from most other audio equipment sold during this time. Input signal is fed to the grid of the 12AU7; direct coupling is used to feed this signal to the second triode stage of the tube. This second stage acts as a phase splitter, and the split signal is then fed to the grids of the 12AX7 push-pull amplifier stage and on to the grids of the 12BH7 cathode-follower driver stage. The cathodes of the 12BH7 are connected directly to the grids of the 6550 output tubes.

Bias voltage is applied to the 6550s via the grid return resistors of the 12BH7 driver stage. Variable damping is also provided to adjust the output to match different types of speaker systems. The impedance matching is selected by a plug and socket arrangement on the rear

PHOTO 1: Pardon the appearance, but these are the risks of buying online.



panel. This selects the proper current feedback resistor for the feedback circuit and damping control.¹

Copies of most Heathkit audio manuals are available from W7FG Vintage Manuals.² The manual for the W6 contains many frequency response charts and data and some very interesting oscillograms. I recommend you obtain a manual if you plan a rebuild.

THE PROBLEM

The W-6M was plagued with stability issues as the 12BH7 aged. This made it difficult to bias the 6550s; sometimes even a new 12BH7 would not allow proper bias adjustment. Heath introduced a replacement, the W-6A,

in 1960.

The W-6A modifications solved these issues. Heath effected slight changes in the circuit with the addition of a bias balancing system and a bias range adjustment. This conveniently allowed for frequent bias checking and adjustment, and allowed the use of less than perfect tubes. Initially Heath eliminated the bias meter from the front panel, but at a later point returned it. (See the schematics for the W-6A and W-6M.)

The 6A was discontinued in 1962, and today the 6M is more commonly seen. The specifications for the W6 series are quite remarkable: 70W of power with a total harmonic distortion level of less than 2% at full rated output, from



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Even more impressive, the frequency response at 1W was ± 1 dB from 5Hz to 80kHz, with a controlled rolloff above 100kHz¹. This was achieved by the use of a heavy, specially designed Altec/Peerless output transformer, which is still generally regarded as having the widest bandwidth and best square-wave reproduction of any transformer produced,¹ capable of easily handling 140W RMS.³ The W6 used a 12AU7, 12AX7, 12BH7, and two 6550 tubes. The oversize power supply and output

transformer make up most of the weight of this unit and are responsible for its outstanding specifications.

The unit also featured silicon diodes in the high voltage supply. Advertising for the W-6M featured these "new" silicon diode additions as advantages, due to the lack of filament heat, their long life, and small size. (The space gained was pretty inconsequential in light of the size of these 50 lb giants.) It is estimated that fewer than 2000 of these monsters were ever produced.³

I obtained my W-6M from an online

PHOTO 2: Working on the Heath W6's innards.

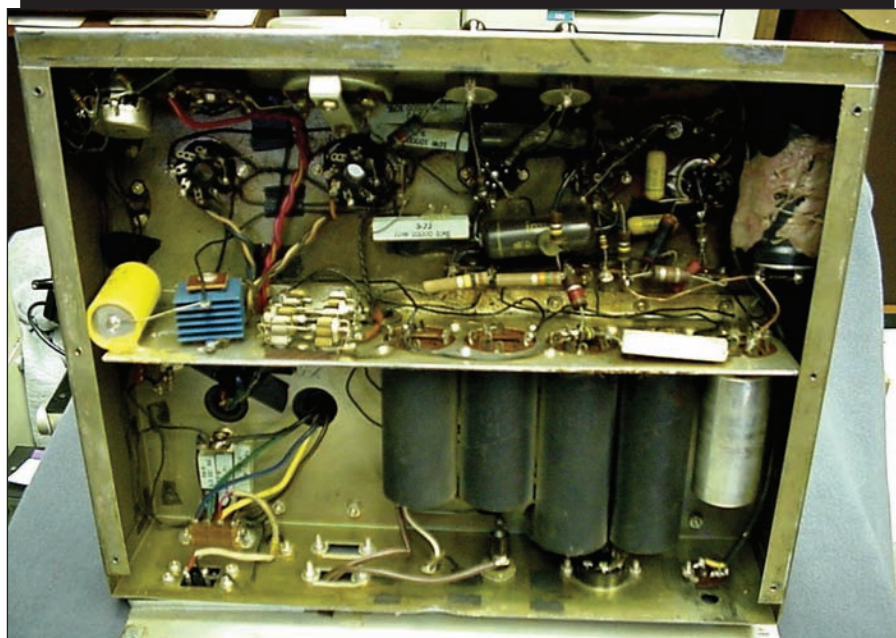


PHOTO 3: Replacing the capacitors.



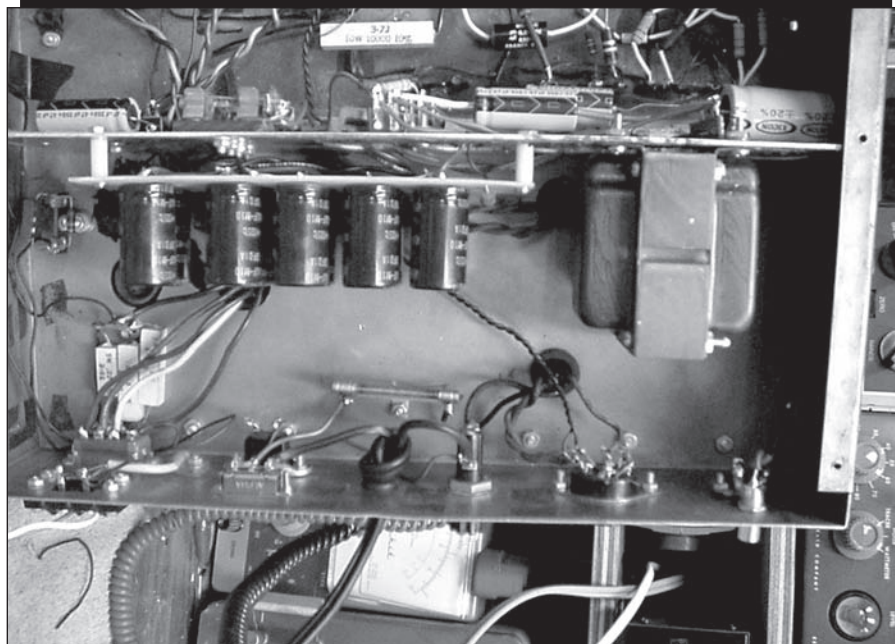
auction. As you can see (**Photo 1**), it was pretty ugly, with tar or paint splatters covering the front and much of the top of the chassis. (I tried to clean these with a variety of solvents and ended up using a high-quality lacquer thinner from a

local body shop, which removed some of the lettering and thinned out the gold paint in some places, but the cosmetics were more presentable.) The seller claimed "it had been used as a guitar amplifier" and had been functioning "be-

fore it was removed from service."

This is a great example of why you need to be careful buying online. When I contacted the seller, he was willing to guarantee the transformers, which was good enough for me. As you can see in **Photo 1**, a filter capacitor had been replaced, secured to the chassis with what appeared to be bubble gum. Bare copper wiring was a fire waiting to happen. Two other filter capacitors were shorted, and several resistors were open. This unit would certainly not have functioned, and it would have been a fire hazard. My advice is to contact the seller before you bid on any piece of vintage equipment to verify its working status.

PHOTO 4: Capacitor board installed.



POWER SUPPLY

I prefer to rebuild the power supply first, and once it is up and functioning, move on to the audio sections. I recommend that you draw a diagram of all existing connections and wiring.

Carefully remove all the wires and resistors from the five can caps, remove the caps from the vertical inner panel, and set them aside (refer to **Photo 2**). Remove the selenium rectifier and associated capacitor and wires. You will now be able to partially remove the vertical panel.

Because most old can filter capacitors are either bad or past their usefulness, and comparable replacements are made out of "unobtainium," I put together a fiberglass board using eight 100 μ F 450V radial capacitors (see **Fig. 1** and **Photos 3** and **4**). These compact units have been very reliable. (I buy several dozen at a time for my tube audio project restorations.) Using two of these in series gives a voltage rating of 900V and a capacity of 50mF per section. By using eight 100 μ F 450V capacitors, you will have the same effective capacitance as the original power supply. As a bonus, this bank will take up substantially less chassis space than the original capacitors.

If you wish, you can add two to four more 100mF capacitors to increase the power supply capacity. I replaced everything past the voltage doubler diodes for the high voltage section.

If you size the board to the same width as the vertical panel, it is easy to use several 1" standoffs to mount your new power supply panel (**Photo 5**).

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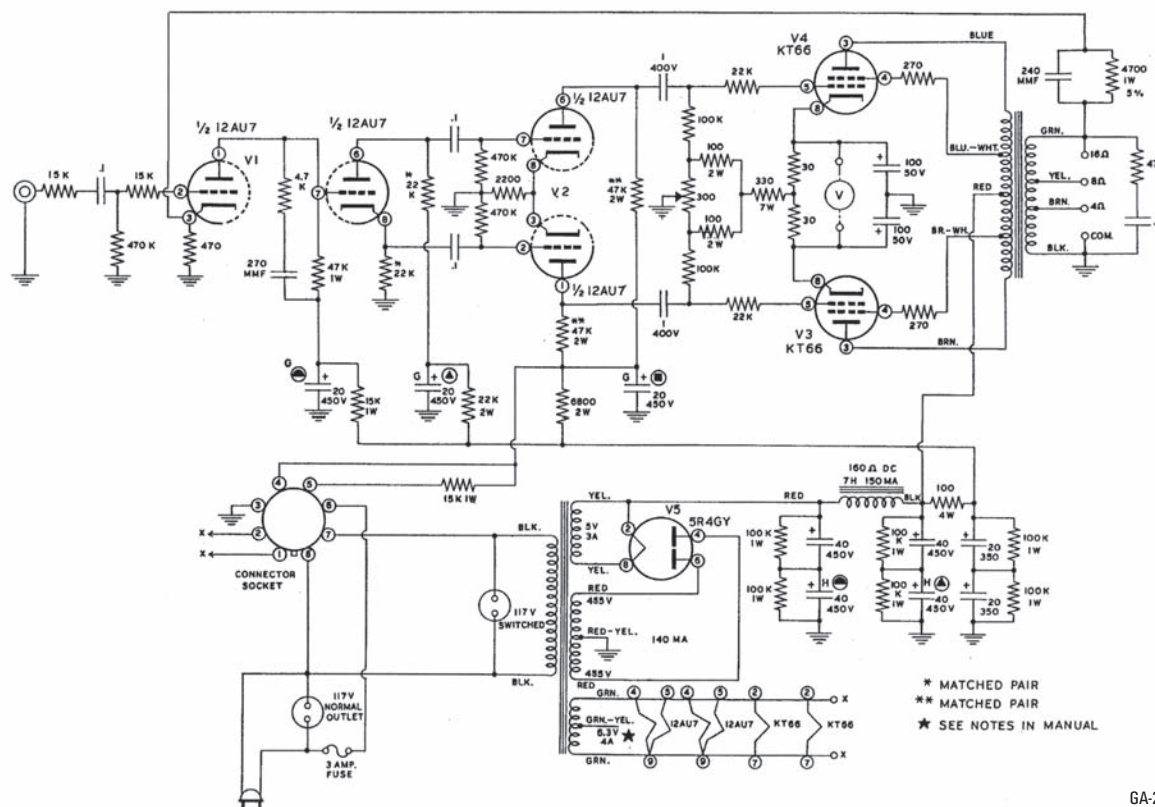
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FIGURE 1: The Heathkit W-5M high fidelity amplifier.



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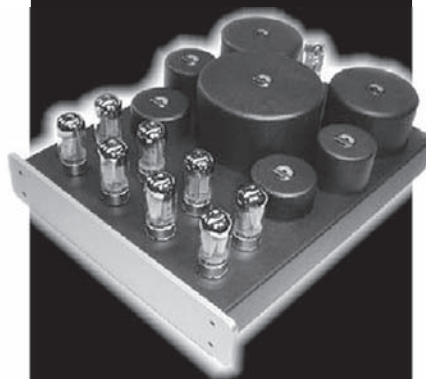
Z56548 Reproduction of the Z565 output transformer as used on the ST35 and SCA35 amplifiers, except that the output taps are 4 and 8 ohms

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To connect the wiring, you will need a length of wire attached to the positive and negative output points on the panel. These will be run through the upright panel to the new additional capacitors associated with the 12GH7, 12AX7, and 12AU7 tubes.

A common issue with equipment designed in the 50s, described in my rebuild of the W5 in an earlier *audioXpress* issue, was that the line voltage back then was around 110V. Today, line voltages are often 120–127V, producing a problem with many vintage amp rebuilds. Dynaco Mark 3 tube amps commonly exhibit this problem. Sometimes the plate voltage on the 6550s will exceed 500V, and even go as high as 550V before the output tubes warm up. This significantly shortens the life of filter capacitors rated for 500V. This is why Dynaco originally used 525V cans, which are very hard to find today.* I tried adding a 5H 200mA choke between the voltage doubler capacitors and the main filter caps to lower the high voltage to the power tube plates. The resulting voltage drop with the choke was about 35V. This modification to the rebuild assures a long, trouble-free life.

In the first trial of my rebuild, by adding the choke I effectively lowered the plate voltage by about 35V, thus affecting the chassis-mounted bias meter reading, but when I used my DVM to set the bias at –50V, the amplifier meter

deflected only three-quarters of the way to the bias mark. I removed the choke to solve this problem, and still managed to keep plate voltage to the 6550s at a reasonable level (452V).

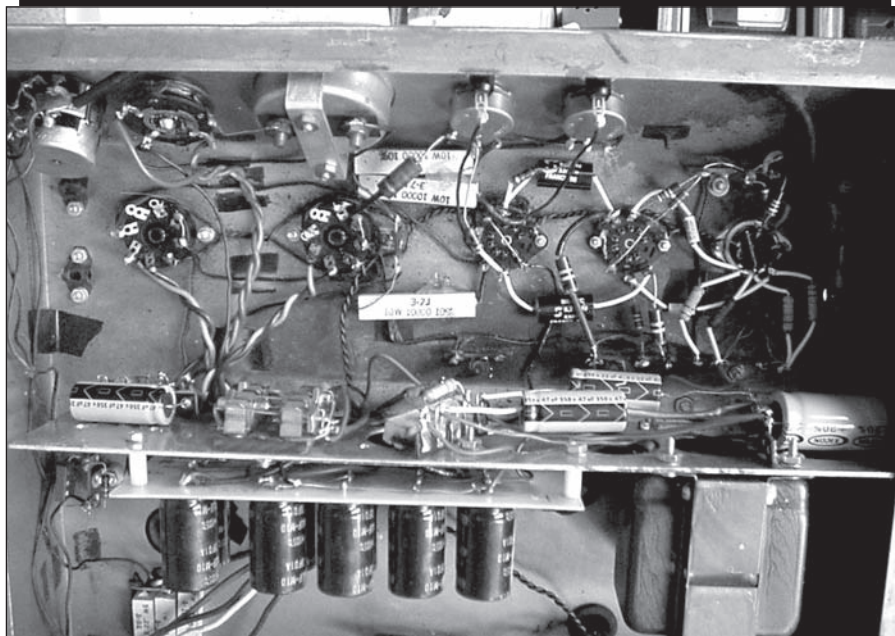
After solving the voltage drop problem, I replaced the selenium rectifier with a silicon diode for the bias circuit, which increased the value of the filter capacitor to 100mF 350V. This helped make the bias voltage more stable during heavy loads.

I replaced one of the rear panel outlets with a DPST slide switch and wired it as an “on-off” power switch. You can use the two wires that run to the rear octal outlet for wiring the switch (refer to the pictorial diagram for the before and after rear panel wiring). The rear octal socket has connections for the AC power to be controlled by an external preamp. You can use an octal plug to connect these two pins, or place a jumper across them.

Some of these amplifiers did not accommodate the surge at power-up; some of the units had a surge resistor on one side of the power line, resembling a small rod wound with wire and a bimetallic strip between either of the ends. As the wire heated up, the bimetallic strip straightened out and shorted across the end terminals, applying full voltage to the power transformer primary.

To reliably suppress the surge when turning the amplifier on, I recommend inserting a three-terminal strip and a

PHOTO 5: Power supply panel mounted.



thyristor (see parts list) mounted in the same position on the chassis. The thyristor works when cold; a several ohm resistance slowly lowers as it warms. This damps a surge that can shorten the life of tube filaments (refer to the pictorial diagram and **Photo 5** for rear panel wiring, before and after).

PARTS LIST

- 8-10 100mF 450V electrolytic capacitors (Electronic Goldmine)
- 2-.27mF 630V film capacitors (AES Solen CFS027-630)
- 2-.0047mF 630V film capacitors (AES Illinois 6-UD0047-630)
- 2-100k 2W metal film resistors (AES R-F100K)
- 2-22k 2W metal film resistors (AES R-F22K)
- 1-27k 2W metal film resistor (AES R-F27K)
- 1-1k 2W metal film resistor (AES R-F1K)
- 1-47mF 450V electrolytic (AES C-ET47-450)
- 1-47mF 350V electrolytic (AES C-ET47-350)
- 1-22mF 350V electrolytic (AES C-ET22-350)
- 1-100mF 160V electrolytic (AES C-ET100-160)
- 1-600V 1A silicon diode (AES P-01N4005)
- 1-SPST or DPST slide switch (optional)
- 1-Thyristor (optional)
- 1-47k 1W resistor (optional-bias range)
- 1-2k 2W pot (optional-bias range)

To test the HV power supply, bias supply, and filament voltages, make sure you have no tubes mounted in the amp. If possible, use a Variac to bring the AC supply up slowly, and monitor the DC voltage. When AC voltage is up to line voltage, the DC should be around +500V DC unloaded. The bias voltage should be around -50-60V DC, and the filaments should be 6-7V AC.

Mount the next section of the power supply on the opposite side of the up-right panel in the amp. This includes the original 12k 10W resistor, a 1k 2W and 27k 2W, plus a 22μF 350V and two 47μF 450V electrolytics. Follow the schematic diagram and connect everything as necessary. This concludes the power supply rebuild.

AMP DESIGN

The amplifier rebuild starts with a careful check of the wiring, testing all the resistors, and replacing the coupling caps. (In my unit, I was not surprised to find a number of resistors that were open or off value; carbon composition resistors often drift in value as they age. When

rebuilding or servicing any vintage piece of equipment, you should measure the value of most resistors and replace them as necessary.) In this W6, the 22k precision resistors were both open, as was the 27k resistor from the power supply, and the 47k -1W on the plate of V1 measured 20kΩ. I replaced the 22k precision units with perfectly matched 2W metal film resistors and replaced all the power supply resistors, most of which were significantly off value.

(I recently discovered an interesting problem with metal film resistors while repairing a vintage amplifier and replacing an open carbon film resistor with a new metal film. On power-up, the amplifier still did not function correctly, and when I measured the replacement, it also was open. I now measure each new component before and after I install it.)

There are four coupling capacitors in this amplifier design. I used .0047mF (4N7) 630 Illinois film caps for the .005s, and .27mF (270H) 630V Solens for the .25μF (250n) "monsters." (I replace all coupling capacitors in vintage equipment because they can be leaky,

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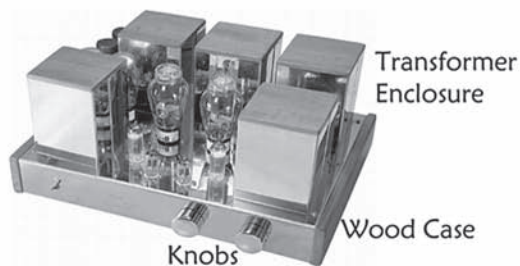
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a frequent problem with large-value coupling capacitors feeding the grids of output tubes, which results in the tubes failing to hold bias.)

When all the wiring and replacing is finished, it is time to place the tubes and test the fix. Insert all the tubes (use a NOS 12BH7 because of the issues with the early versions of W6 and stability and biasing of the 6550s), turn the bias pots to the fully counterclockwise position, and set the meter switch to off. There is no need to connect speakers or an audio source at this time. Power up the amplifier, and after the tubes have warmed up, connect your DVM to the chassis and to pin 5 of one of the 6550s. Adjust the bias control for that tube to indicate -50V on the DVM. Do the same thing to the other 6550. (If you are not able to set these voltages, you should measure all the voltage test points in the amplifier to determine the source of the problem.)

If the bias holds steady, check all the voltages listed in the Heathkit manual, which should measure to within 10% of their listed value. Check the accu-

racy of the built-in bias meter by setting the switch to each position and noting whether the meter deflects to the set mark (with your bias set by the DVM). The metering system in the W6 measures the current draw through the center taps of the output transformer from the high voltage supply. If your high voltage power supply differs from factory specs, the meter reading will not accurately reflect the actual bias current.

As described earlier, I lowered the plate voltage with a choke, but decided later to remove it to allow the correct use of the bias meter. You could also increase the capacitance of the voltage doubler section of the power supply and boost the voltage before the choke. Alternately, you could re-mark the meter face with the bias set at -50V as measured by your DVM. Do what works for you, but it is very important to check this bias setting often and compensate for the aging of the 12BH7.

If everything measures correctly, power down the unit, hook up a speaker and input source, and power it back up. You will be amazed at the ability of this

amplifier to drive virtually any speaker system, and how cool the unit runs. After several hours of significant use in my shop, the transformers were only slightly warm to the touch; even the 6550s were touchable.

FINE-TUNING

With some trial use, I started having the same issues with bias adjustment as described earlier with the W6Ms. I decided that it made sense to modify this amp to the W-6A style by replacing the 56k 1W resistor between the bias pots and ground with a 47k 1W resistor in series with a 2k 2W pot. This simple modification allows an increase of the available bias voltage to balance aging tubes.

To avoid drilling extra holes in the original chassis, I removed the octal power socket from the back panel

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and made a plate to mount the new control. Run a pair of wires from the front-mounted bias controls where the 56k resistor is connected (necessary because this amplifier is wired with all the ground connections tied together and grounded only at the input connection). This prevents ground loops.

I also added another terminal strip and moved the filament windings and connecting wires to the strip. Because of the original wiring design, the filament winding from the power transformer goes to the back socket and the twisted wires go to the rest of the amplifier. It is also important to ground the center tap of the 6.3V winding. Failure to do this will result in 60Hz hum.

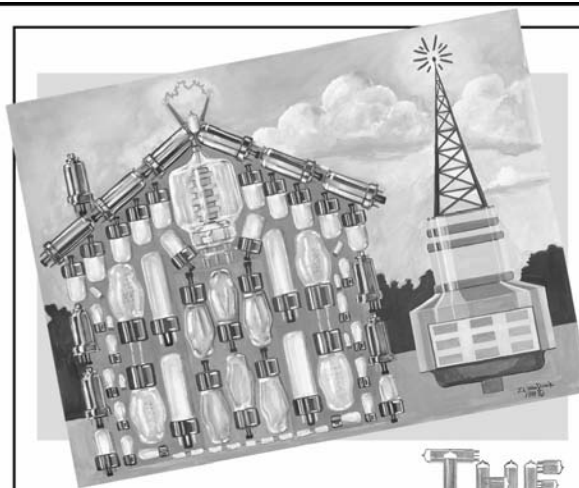
Though not a thing of beauty, the Behemoth, even after extended listening, is one of the most pleasing tube amps I have ever heard. It is extremely musical, and listening for long periods of time is effortless. Now I would like a second one, to listen in stereo! *ax*

* Keep in mind that domestic voltages in the US routinely vary with demand over the course of a day. Use a Variac to set bias properly.—ETD.

REFERENCES

1. Heathkit High Fidelity Amplifier Model W-6M Assembly and owners manual.
2. www.w7fg.com.
3. *Vacuum Tube Valley*, Issue 2, Fall 1995.

Bruce Brown is a registered pharmacist, working in the medical research area for a major pharmaceutical company. He has been experimenting with electronics for over 30 years. His earliest interests involved tubes salvaged from castoff TVs. He serviced audio equipment during college. Over the years he has remained actively interested in electronics, building kits and "home brew" audio. Online auctions have stimulated new interests in restoring vintage audio equipment. Only recently has he become interested in writing articles to assist other hobbyists. His wife, Kristin, has been an invaluable help with editing his ramblings. He currently uses many restored and home-built audio amplifiers. He welcomes communication about vintage equipment and restorations. He can be reached at Tuninfork@aol.com.



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