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Title: Converting a Heathkit SB-220 Amplifier to 6 Meters
Author: Steve Gilbert, K1SG

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Converting a Heathkit SB-220 Amplifier to 6 Meters

Make a big noise on the "magic band" with that old amplifier.

Steve Gilbert, K1SG; John J. "Mick" McManus, W1JJ, and Mike Chirkov, UN8GC

The Heathkit SB-220/SB-221 series of HF linear amplifiers has aged well. Heath sold them by the thousands in the 1970s and '80s. They seem to turn up at every flea market and online auction. While some have suffered the ravages of time, many SB-220s have survived very nicely, and are still on the air. An article in January 2007 *QST* by Tom Sowden, KØGKD, details the restoration of such an amplifier.[1] While his aim, *restoration,* is different from ours, the information he provides is extremely helpful background reading before undertaking the 6 meter conversion.

Several SB-220 conversion schemes have been published that "minimize the damage" to allow the amplifier to be easily reconverted back to its original functionality. Those conversions utilize an existing bandswitch position to allow the amplifier to function on both HF and 6 meters. We'll have none of that here! Our conversion produces a 6-meter-only amplifier; the unit is far simpler, more efficient and couldn't be more stable — and that's what we wanted. For this article, we will assume that you already have an SB-220 or SB-221. Functionally they're almost identical, other than the added complexity of the 10 meter bandswitch position in the '220. All of that will be removed anyway.

[1]Notes appear on page 40.

Where Do We Come From? What Are We? Where Are We Going?

Before getting started on the conversion, we need to know how the amplifier works. Does it put out full power? Is it stable? Are any parasitic oscillations generated? Do the parasitic suppressors seem "toasted"? It's useful to record the operating parameters of the amplifier before you start any conversion, preferably on 10 meters, or 15 meters with a '221.

Once we know that we have a good amplifier, we still need to bring it up to speed before the 6 meter conversion is started. In the later SB-221s, the power transformer was connectorized, so it could be removed easily. This amplifier was going to be shipped to Kazakhstan. USPS regulations make it far less expensive to ship two boxes that each weigh less than 44 pounds than to send one box weighing more than that, so this was our first step. Removing the plate transformer provided several additional advantages:

- It made it much easier to work around the high voltage section of the amplifier.
- Low voltage testing (relay and bias switching, for example) was facilitated.
- The amplifier became a whole lot easier to move around — we're not getting any younger!

This was also a good time to add a Harbach Electronics SoftStart module to lengthen tube and power supply life. For our updating, we decided to replace the high voltage (HV) capacitor stack with modern replacement capacitors. By doing that, we essentially doubled the stack's capacitance in slightly less space, improving the regulation and linearity of the amplifier. The HV diode stack went next, and the simplest solution here was to utilize K2AW rectifier stacks. As always, they worked perfectly. We also decided that the open frame relay had to go, since it added loss and degraded the input SWR badly. Since we were already work-

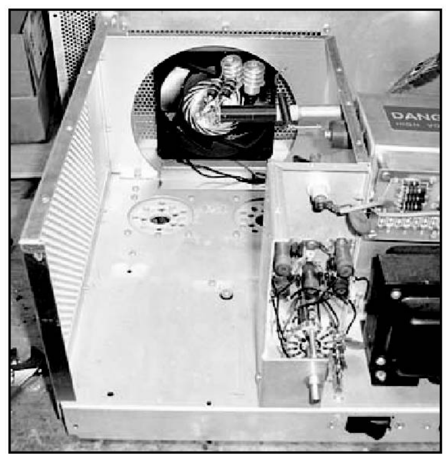

Figure 3 — Look Ma, no plate circuit!

Figure 1 — The connectorized transformer, new capacitor bank and diodes.

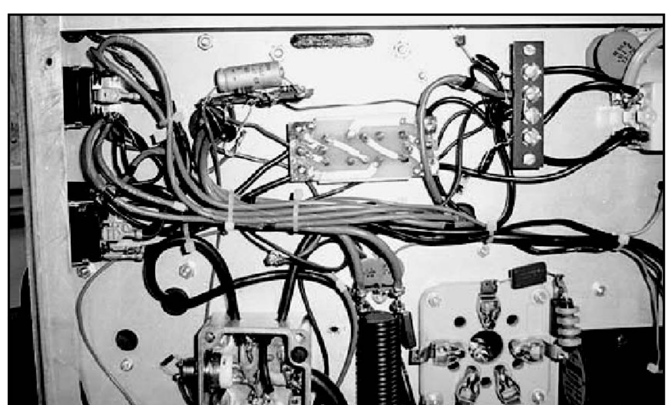

Figure 2 — Underside view of SoftStart and primary wiring.

ing on the relay, it was a good opportunity to check and replace the 1N3996A Zener diode. A list of all these parts and the full schematic are located on the ARRLWeb.[2]

For the conversion, we were committed to totally removing the input and output tuned circuits and the bandswitch. We also replaced the parasitic suppressors while we were there. We also made the decision *not* to directly ground the grid pins, but rather leave them as in the Heath design — more on this later.

The Execution

We did the upgrades first, so we could test the amplifier before converting it to 6 meters. After unplugging the amplifier and making *absolutely certain* that the HV has bled down completely, short the high voltage to ground and take the amplifier out of the outer cabinet. We removed the power transformer and cut off the leads from the transformer as long as possible, but left an inch or so where they were soldered into the circuit so we could follow the same color code. We used 4-pin inline Molex connectors and HV wire for the high voltage secondary side, separating the two leads as much as possible.

For the primary side, since voltages were under 250 V, we used 6-pin AMP connectors and 14 gauge wire. We made all of the plug-in connections available from the top side of the chassis, so that the transformer could be easily removed by unplugging two sets of connectors and unscrewing four bolts. See Figures 2 and 3.

While we worked on the primary side of the transformer, we installed the Harbach SoftStart PC board. On the secondary side, we replaced the HV power supply capacitors, diodes and bleeder resistors. Once these changes were made, we reassembled the amplifier and confirmed that it still worked. Miracle of miracles, it did — with slightly higher plate voltage and power output.

The Point of No Return

Next, we removed the front panel and the tuned circuits. From this point, there was no turning back! The plate circuit came out easily. The band switch and input LC circuits took a little more work, but as shown in Figure 3 it all came out.

We reused the original plate tuning capacitor as the load capacitor, and installed a 100 pF 4 kV variable as the new tune capacitor. The plate tank coil is 0.25 inch copper tubing air-wound on a 1.25 inch form, with 3 turns spaced out 3 inches long as shown in Figure 4.

The shield to which the input tuning coils were mounted was augmented by a piece of PC board, to maintain good input to output shielding. The new tuned input circuit replaces the bandswitch. It is a T-match consisting of two identical inductors, each 10 turns of 22 gauge enameled copper wire wound on ⅝ inch threaded rod, the rod is removed and the coils are spread over 1 inch and an input tuning capacitor, a 50 pF variable rescued from the junk box. Figure 5 gives the idea.

Figure 4 — New plate and input circuits. The original parasitic suppressors remain.

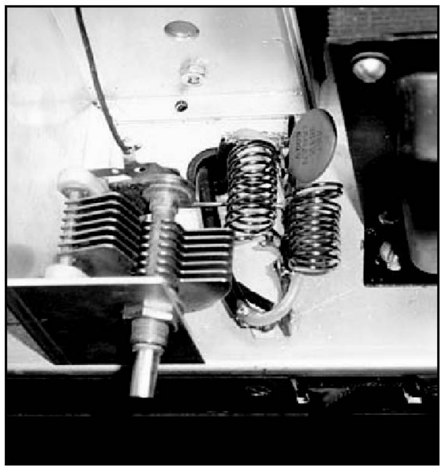

Figure 5 — New 6 meter input tuned circuit.

Figure 6 — Vacuum relays are in the die-cast box. The 12 V power supply and bias relay are located below.

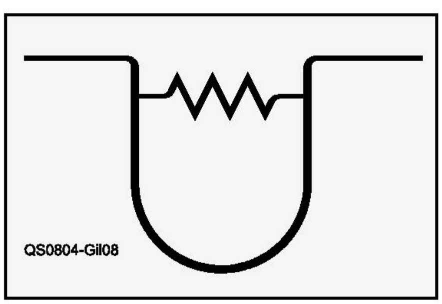

Figure 7 — Detail of parasitic suppressors. See text for construction details.

Make it VHF Friendly

The open frame relay in the SB-220 has a checkered history. Many folks report having to "tune the relay" on 10 meters because it causes a huge SWR discontinuity at the higher frequencies. We opted to tear it out and replace it with two vacuum relays. Most surplus vacuum relays run on 26 V dc, but Gigavac makes a 12 V version available with ham-friendly pricing. The vacuum relays were mounted in a small Hammond enclosure. The original relay ran on 110 V dc, which is not a user friendly voltage for solid state radios.

Instead of using a battery, or stealing 12 V from the exciter, we opted to build a tiny 12 V power supply on the underside of the chassis for a small 12 V relay to switch bias and the vacuum relays. This is shown in Figure 6. At this time, we also decided to remove the automatic level control (ALC) circuit; it was one more complication we didn't need.

Avoiding Improper Bias

This was a good time to replace the capacitor and the Zener diode in the bias supply. We observed one very curious attribute of most of the Zeners we found — the voltage was much lower than expected. The 1N3996A is listed as a 5.1 V diode, but we had to go through several to select one that had a Zener voltage close to that value. It's not a magic value, but when we replaced the diode, idling current (and heat) were reduced. This testing was easily accomplished with the HV power transformer removed. It should *never* be attempted when HV is present!

Maintain Your Stability

Stability is a central question with amplifier conversions, and we considered our choices. We found that in changing out the RF relays, it was possible to shorten the coax cables and run them a little more directly. We could also improve the shielding between input and output sections. In articles by AG6K, conversations with K1KW, KM1H and W1QJ, a number of suggestions were floated on the subject of parasitic suppressors.[3-5] The solution we employed for each suppressor assembly was to form an extended U shaped piece of Nichrome steel ribbon.[6,7] The ribbon is ¼ inch wide and about 5 inches long. Each unit has three 150 Ω, 2 W resistors in parallel running between the edges of the U. We also used the Nichrome ribbon to connect between doorknob capacitor C29, and the junction of RFC1 and the suppressors to ensure that this section of the amplifier is as low-Q as possible. See Figures 7 and 8.

Heath designed the amplifier with the grids at RF and dc ground by virtue of capacitors and RF chokes from the grid pins on the

Table 1
SB-226 Operating Parameters

Function	*Drive (W)*	*Plate Voltage (V)*	*Plate Current (A)*	*Grid Current (A)*	*Input (W)*	*Output (W)*	*Efficiency (%)*
CW/Tune	65	2350/2000 V	0.620	0.250	1240	730	58.8%
SSB	80	3050/2500 V	0.760	0.250	1900	1100	57.9%

High power output is greater than the 1 kW slug can measure. It looks like the meter was about 10% over range for 1100 W out. Plate voltages shown refer to no load/key down conditions.

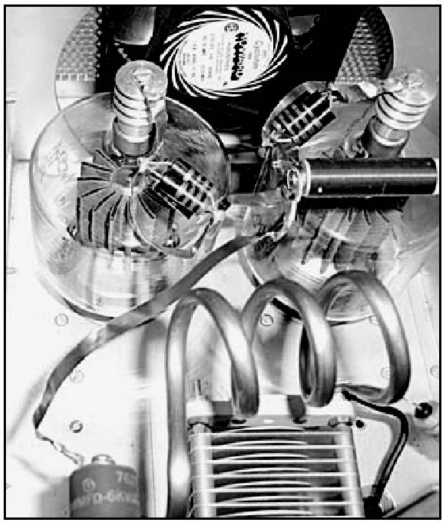

Figure 8 — Note the piece of Nichrome ribbon leading from RFC1 to doorknob capacitor C29.

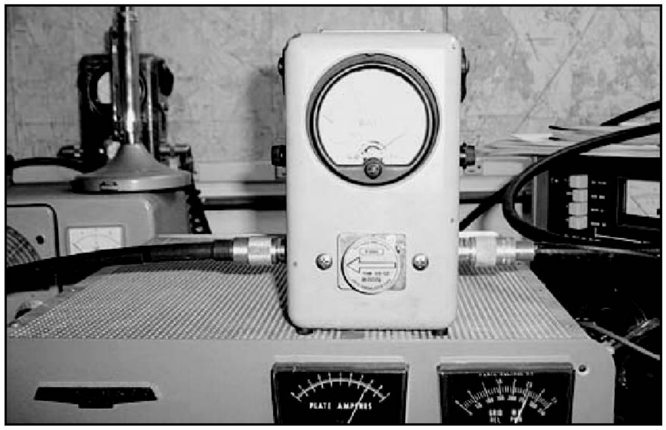

Figure 9 — Glare prevents a clear view of the Bird meter being buried on a 1 kW slug.

socket. The RF choke functions as a fuse in case there is a parasitic oscillation, and the choke is a lot cheaper to replace than the tube! The good news is that the amplifier really wants to be stable. In testing so far, there are no signs of instability or heating. That dreaded burning smell is missing in this amplifier. The operating parameters of the amplifier are listed in Table 1.

So How's it Play?

Steve's first contact was with K1TOL, about 200 miles away in Maine (grid square FN44). He said the amplifier sounded great, had no splatter and just made us sound louder — just as it was supposed to. Lefty knows Steve's voice well, and would have noticed any distortion. The next contact was with John, WZ8D, in Ohio (grid square EM89), at a distance of about 800 miles via scatter. He also thought the amplifier sounded great, and was happy to enter the contact in the log. After testing with several local stations to make very sure we were clean, we gave the amplifier its initial trials off the moon. After running for over an hour with Ian, G5WQ, under miserable Earth-Moon-Earth (EME) conditions, the amplifier was perking along very happily. Although we did not complete the contact because of noise at the US end, Ian copied us well for many sequences.

While the SB-220 can operate SSB in the high power position (see Figure 9), you can't leave a brick on the key. The amplifier is not rated for 100% duty cycle operation. For high duty cycle modes the amplifier *must* be used in the low power position, and 700 to 800 W output is enough to make EME contacts.

The final test of the amplifier still awaits. We'll know it works when K1SG and W1JJ are in the log of UN8GC. In late-breaking news, while we were preparing this article for publication, W1JJ and UN8GC have made contact via the moon. One down — one to go!

Special thanks to W7GJ for his many contributions to the project; to K1JT for his wonderful program *WSJT*, which makes 6 meter EME accessible; to W1JZ, WA1JKI, GJ4ICD and G5WQ for their assistance, and also to N1DJB who suggested the underlying philosophy — "Overkill is never enough!"

Photos by Steve Gilbert, K1SG

Notes

[1]T. Sowden, KØGKD, "Old Amplifiers — Boat Anchors or Bargain Basement Opportunities?" *QST*, Jan 2007, pp 37-41.

[2]**www.arrl.org/files/qst-binaries**.

[3]R. Measures, AG6K, "Improved Anode Parasitic Suppression for Modern Amplifier Tubes," *QST*, Oct 1988, pp 36-38.

[4]R. Measures, AG6K, "Circuit Improvements for the Heath SB-220 Amplifier," Part 1, *QST*, Nov 1990, pp 25-29 and Part 2, *QST*, Dec 1990, pp 41-43.

[5]R. Measures, AG6K, "Improving the Heathkit SB-220 Amplifier," Hints and Kinks, *QST*, Feb 1989, p 42.

[6]Nichrome is an alloy of nickel, chromium and iron that has a much higher resistance than copper wire. It is commonly used as a heating element.

[7]Suppressor retrofit kits including both Nichrome steel wire and strip, as well as silver solder and flux are available from Rich Measures, AG6K, at **r@somis.org**.

Steve Gilbert, K1SG, has been licensed since 1963 at age 13, He was WA1AYS for over 30 years before receiving his current call, K1SG. Steve got on 6 meters during junior high school in 1964 and hasn't come out of the basement since. He made his first 6 meter moonbounce contact in 2005. He holds an Extra class license.

Steve attended Tufts University and then became the all night announcer for WCRB, the classical music FM station in Boston. In 1975 he started a print and copy business with one press operator that grew over time to 15 employees. Since 2002 he has been consulting — primarily in the print/copy industry. You can reach Steve at 75 W Elm St, Hopkinton, MA 01748-2126 or at **k1sg@aol.com**.

Mick McManus, W1JJ, was first licensed as KN1IKN in 1959. He held the calls K1IKN and W1JJM before receiving his current call in 2003. He holds an Amateur Extra class license. He has been active on 6 meters since 1959 with his 6 meter EME attempts beginning in 1971.

For 20 years, John was the head of the Communications Division of the Warwick (Rhode Island) Fire Department. He is now co-owner of Intouch Communications, LLC. You can reach John at 50 Austin Rd, East Greenwich, RI 02818 or at **w1jj@aol.com**.

Mike Chirkov, UN8GC (formerly UL7GCC), has been active on 6 meters since 1992. He has now completed his first EME contacts with W7GJ, K6MYC and W1JJ. Can K1SG be far behind? You can reach Mike at **mike.chirkov@un8gc.com**.