8877 "Lite"—A 50-MHz 20-Pound Travel Amplifier

K5AND lets us in on how to break your score without breaking your back.

By Dick Hanson, K5AND

As those of you who do expeditions and mountaintop contesting can attest—carrying a kilowatt amplifier on your quest is *so* much fun. Over the years since 1987, I have built or modified five travel amps, all for 6 meters. The first was a highly modified Tokyo Hy-Power HLK-1A, followed by a Yaesu FL-2100, followed by a single 3CX800 (for W6JKV), followed by a pair of 3CX800s, followed by a single 8877 with separate power supply, followed by a single 3CX800 with built-in high voltage supply with a smaller (lighter) high voltage transformer.

These amplifiers all had one thing in common—they were a real challenge to transport. The last one was the best of the lot with respect to both footprint and weight, but still weighed in at 30 pounds, minus blower, plus 12 pounds for the luggage bag for a total weight of 42 pounds. I wanted a carry-on package that would weigh less than 30 pounds and, available wall voltage notwithstanding, an amplifier that would deliver 1500 W under normal conditions.

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Time for an Extreme Makeover?

It's pretty hard to "shrink" a conventional high-voltage power supply, even with careful sizing of the transformer, smaller filter capacitors, etc, but it is the power supply that offers the most potential for shedding pounds.

Ever since seeing a prototype regulated high-voltage switching supply in the Command Technologies booth at Dayton several years ago, I've dreamt about imbedding a high voltage switcher in an amplifier. Watts Unlimited was the first commercial entry into the high-voltage switching arena, so after months of studying the product and asking questions of its creator, I decided to try one.

Most "new" technologies have pros and cons, so you must evaluate both.

The "pro" side of the Watts Unlimited PS-2500A[1] is:

- At 10 pounds, it's a lightweight.
- It provides reasonable voltage regulation from idle to full-load (within about 10%).
- It's electrically *quiet*—this supply is only on during transmit.
- It's capable of supplying enough power for a 1.5 kW RF output amplifier,
- Instead of providing a fixed bias in the cathode (assuming triode tubes) and then changing the bias from cut-off to operate with a cathode

[1]Notes appear on page 46.

relay, in this amp, *there is no cathode relay*. Since there is no relay to switch from cut-off to operating bias, the tube will draw idle current as soon as the PTT circuit is activated. This eliminates at least several components from the amplifier.

"Cons" to keep in mind include:

- The supply cannot be turned on without a load. To do so would be to guarantee a failure of the output capacitors, as the resulting high voltage would soar over their 4 kV rating. The manufacturer recommends a minimum idle current of 150 to 250 mA at turn-on. So if you're going to use a Zener diode for the operating bias, you should select a Zener that will make the tube draw at least 150 mA at idle.
- Another thing to consider is that the supply does not come "on" when you turn on the ac power switch. It requires an external nominal 5-12 V dc source to switch it on. The user needs to provide a dc on-off source voltage activated by the PTT circuitry. While this is not an obstacle, you need to be aware of this requirement in your planning.
- The power supply includes two "fail safe" modes which will take the supply off line. Additional safety circuitry is highly recommended to prevent the amplifier from being keyed in the absence of anode voltage, which could damage the tube. This additional protection can take the form of a grid-trip circuit or an absence of B+ circuit.

Design Criteria

Let me say now that this is more of a *concept* article than a complete nuts and bolts, step-by-step how-to article. That said, if you have built an amplifier before, you should feel right at home with this material.

Because of my requirement for 1.5 kW RF output, and because of the regulation characteristics of the power supply, it seemed that a single 8877 would be the easiest tube to implement. Also given consideration were 3CX800s. For this application, the single 8877 best matched the power supply idle current requirement.

With the 8877 idling at 150 mA, the instant the supply is switched on, the anode voltage is 3400 V. At full load of 850 mA, the anode voltage drops to 3 kV. The power supply remains cool and electrically quiet while "dormant" even though 240 V ac is present. When the PTT is activated, the supply goes from 0 V to full output in a few milliseconds.

Features of the amplifier are:

- It fits in a relatively small box—6.5×13.5×12 inches (HWD, less blower). See Figs 1 and 2.
- It weighs a mere 20 pounds, including the built-in power supply.
- There are no protrusions from the cabinet to break in transit.
- There are no knobs, screwdriver adjustments are provided for the plate and load capacitors.
- A flush plug and socket is provided for the ac line entrance connections.
- Plate and grid meters are protected

Fig 1—Front view, showing exhaust port on left, plate current meter on top at center, grid current meter at center, recessed power switch and amplifier IN/OUT switch with ground-trip LED above. On the top, the removable knob on the upper right is PLATE TUNE. The lower removable knob is PLATE LOADING. The air intake for the power supply is on the bottom of cabinet. The RF compartment is pressurized so that 95% of the air exhausts through the anode cooler and the rest exits thru the cathode compartment.

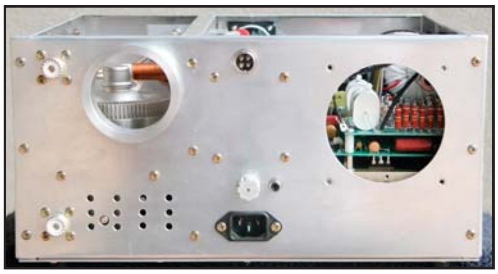

Fig 2—Rear view, showing RF input and output connectors at bottom left and top left, the mounting flange for the blower, cathode compartment air exhaust (under blower flange), ac power connector for blower and fan in upper center. The fuse, RCA PTT connector, ac mains connector and hole for the muffin fan at far right. Both openings are "screened" with stainless screening. Teflon chimney with rubber "extension" for pressurizing anode compartment.

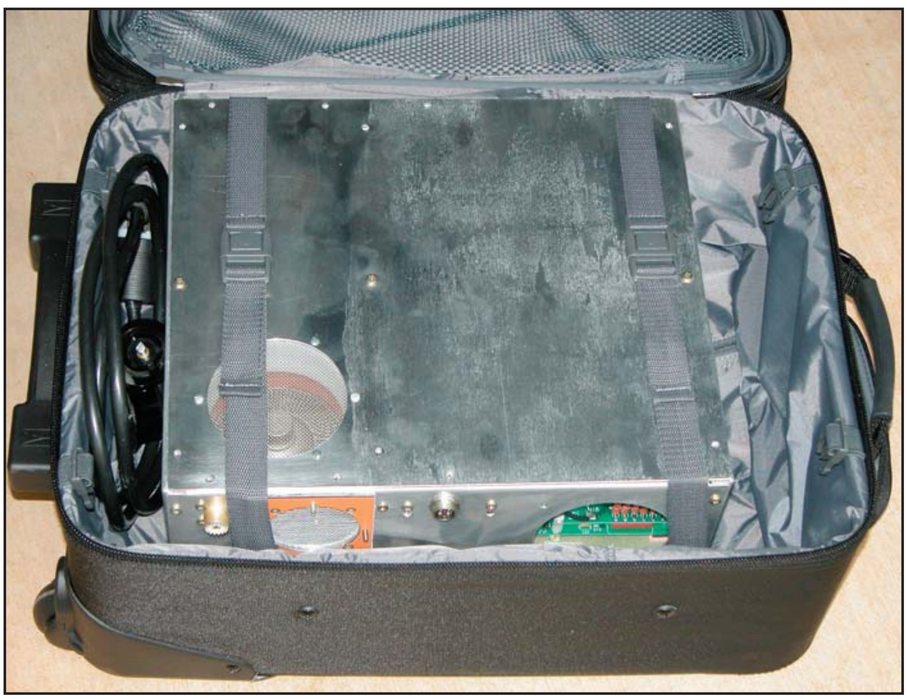

Fig 3—The amplifier packed in its Travel Pro bag and ready to go.

behind the front panel.

- A 3 minute time delay holds off PTT until the cathode warms up.
- It is provided with built-in RF input/output relay switching.
- A vacuum plate capacitor and physically small meters help shrink the cabinet.
- It fits inside a rolling carry-on Travel Pro bag (8 pounds)—these bags are made of Teflon-coated ballistic nylon and are lightweight, durable, strong and water-resistant. Best of all, they have really great wheels and an extendable handle. See Fig 3.
- This amplifier may not win any beauty contests, but it must be rugged.

Building the Amplifier

For me, the hardest part of a project is planning the metal work, which of course is dictated here not only by the size of the components, but also by the airline size limitations for "carry-on baggage." Charlie Byers of Byers Chassis supplied the chassis and its interior metal work. I had some more metal work done by a local machine shop, and I used imbedded captive nuts for cabinet assembly rather than gambling on my fat fingers trying to get a nut on a screw. Details of the cover sheet metal work are shown in Figs 4 and 5.

Since this is a single band (in fact, almost single frequency) amp, it does not require much tuning. So if you can eliminate the protruding tuning knobs—why not? I made a couple of knobs with 1/4 inch shafts and then filed the ends of the shaft stubs to resemble a flat-blade screwdriver end. These assemblies are temporarily inserted into the plate and load panel bushings on the front panel so that you can in fact tune with a knob in "set and forget" fashion; the knobs are then removed for transport. The cathode tuning capacitor is also a screwdriver adjustment, and once set, will hold tuning over at least 1 MHz.

This amplifier uses a conventional π circuit instead of a π-L configuration to save a little more space. I always carry a high-power ICE 6-meter filter in the suitcase, so I have no worries about second harmonic rejection. The blocking capacitor is an "857" type, rated at 15 kV and a lot of current.

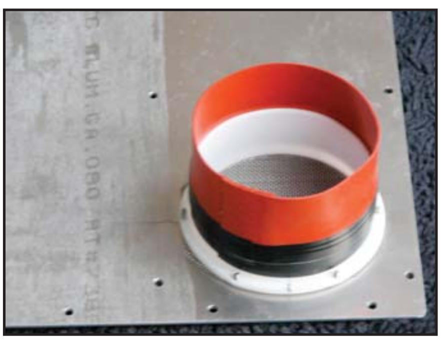

Fig 4—Top cover sheet metal detail including chimney mounting.

Fig 5—Bottom cover sheet metal.

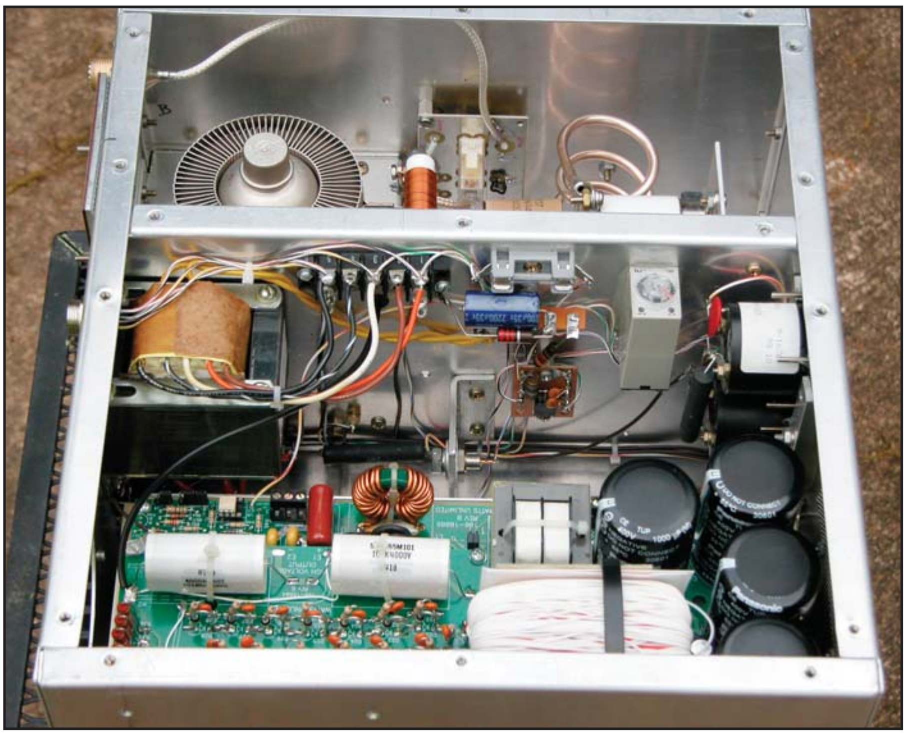

Fig 6—Another view of RF deck, showing the 8877, anode clamp and input/output relay-switching board, featuring the Schrack relays. Also note the Teflon RG-142 coax for the output. This coax will handle the 1.5 kW without meltdown! Also shown is part of the control circuitry—the Omron time delay relay and Tripplett 120G series plate and grid meters. The fuse at the center is for the amplifier cathode circuit. The filament/control transformer at the left is an Ameritron 406-1419-3J.

The RF input/output relay board is the same one I have been using for a number of years now. The SPDT Schrack relays have very robust contacts. The amplifier off-line VSWR may be "tuned out" using a thru-line capacitor ground trick shown me by Pat Stein, N8BRA, of Command Technologies and mentioned in an earlier article.[2] See Fig 6.

The three-minute time delay for cathode warm-up is provided by a common Omron H3YN-2, 0-10 minute delay relay; the delay is set for three minutes. It seems like an eternity when the band is open and the amplifier is warming up!

The power cord set is a heavy duty IEC arrangement featuring a standard three-prong male chassis mount connector mated to a 3-wire, 12 gauge power cord about 8 feet long. The plug end is left unterminated so that you can put on whichever male plug may be required for the country you're visiting. Again, this "connector" approach on the amplifier was used to eliminate protrusions which can be damaged in shipment. The ac mains are turned on and off by a recessed DPST switch rated at 10 A at 250 V ac. The filament and control voltage transformer is an Ameritron unit; PN 406-1419-3J; $49.95.

The plate RF choke is wound on a $^1/_2$ inch Teflon rod, using 42 turns of 20 gauge Formvar insulated copper wire. The bifilar filament choke is 10 turns of 14 gauge Formvar insulated copper wire wound on a 2 inch long $^1/_2$ inch diameter ferrite rod. See Fig 7.

The cathode choke is a Z-50 (7 µH) unit. Don't forget to install another Z-50 RF choke from the output loading capacitor terminal to ground to protect you from a shorted blocking capacitor. L1 and L3 are described in the RF deck section.

Tripplett 120-G series meters are used for the plate and grid metering since they are physically small and are high quality devices. They are protected from abuse by being mounted behind the front panel. The grid meter is a 100 mA unit and the plate meter is a 1 A unit.[3]

Grid over-current protection is provided by Q2 and its associated circuitry. The 5 kΩ potentiometer in the circuit allows the trip current to be set in the range of 40-150 mA, which is adequate for the 8877. When the preset current is reached, Q2 conducts, which in turn closes K4. One set of it's contacts locks the relay ON and turns on the TRIP LED; the other set of contacts opens the +15 V control bus to the PTT circuit, thus taking the am-

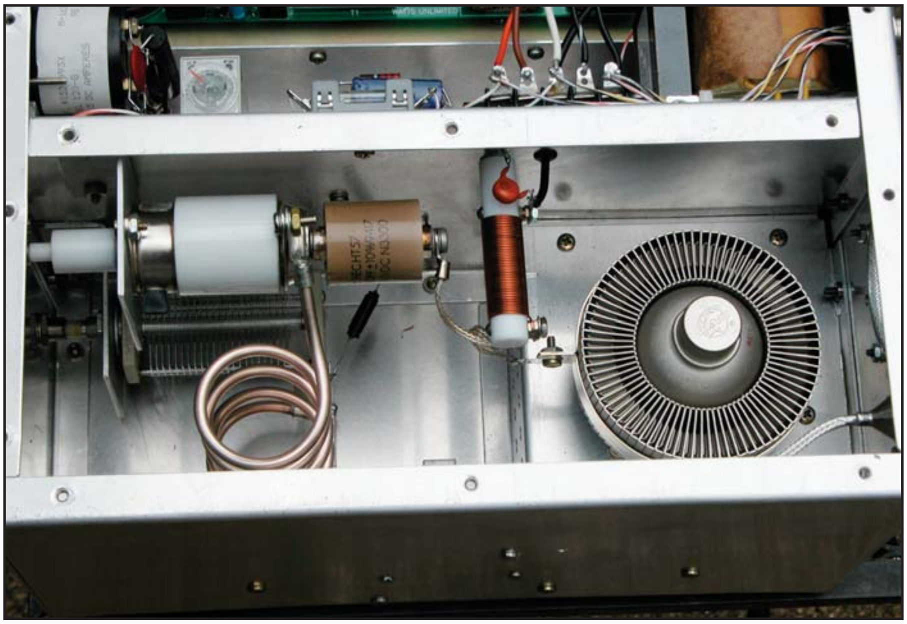

Fig 7—Larger view of the tank circuit, showing the silver-plated tank coil, 3 to 30 pF vacuum variable capacitor, 857 blocking capacitor, RF plate choke and, almost buried at the bottom, the 200 pF loading capacitor.

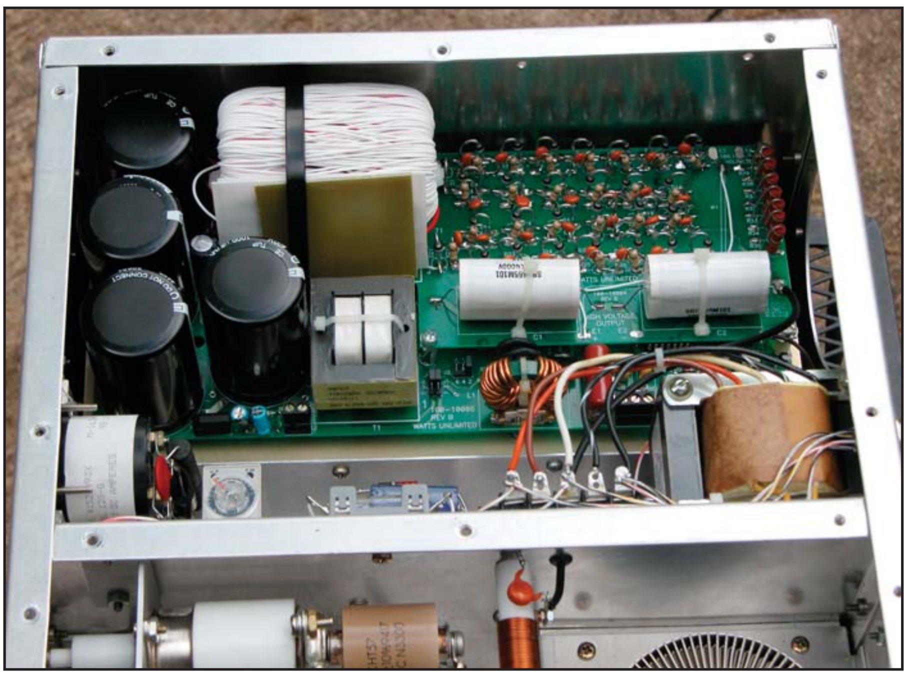

Fig 8—This shot shows the PS-2500A high voltage switching power supply. The white object at the top left is the high voltage transformer. The two high voltage output capacitors are at the center right. The total output capacitance is 0.2 µF at 4000 V dc.

Fig 9—Top view, showing the Watts Unlimited PS-2500A switching power supply at far left. The center section houses the control circuitry, including filament transformer, time delay relay and metering. The RF compartment is on the far right.

plifier off-line until the over current condition has been resolved. Depressing the normally closed push-button switch resets the trip circuit.

To pre-set the grid-trip value, apply +5 V dc through a 500 Ω potentiometer to the junction of the grid and plate current meters. Adjust the temporary pot for some not to exceed value of grid current, say 100 mA for example. With the pot at maximum resistance, gradually turn it towards minimum until K4 trips and the TRIP LED comes on.

Specifications

There are no surprises here. With 40 to 50 W of drive, the amplifier will put out 1500 W with 2500 W dc input. The anode voltage is about 3000 V under a load of 850 mA. Grid current runs between 40-60 mA with this loading and anode voltage.

If you have an MFJ-259 or similar antenna analyzer, all the preliminary tuning can be accomplished before applying the high voltage. Getting the cathode and tank circuits "in the ballpark" before applying drive is always a good feeling.

Installation of PS-2500A Power Supply

The good news is that there are very few connections required to interface to this unit. The sobering news is that any mistakes are either costly, dangerous or both. Fortunately, the manufacturer has done a very nice job with documentation—the manuals are excellent. I would suggest taking extra time reading and understanding the manual especially regarding the following points (see Figs 8 and 9):

- AC connections, including neutral
- B minus
- HV turn on-off
- B plus connection
- Metering
- Jumpering

The supply factory default wiring is connected for 240 V ac mains as shown in Fig 10. The default jumpers are also set for the B minus connection tied to chassis ground. Most lin-

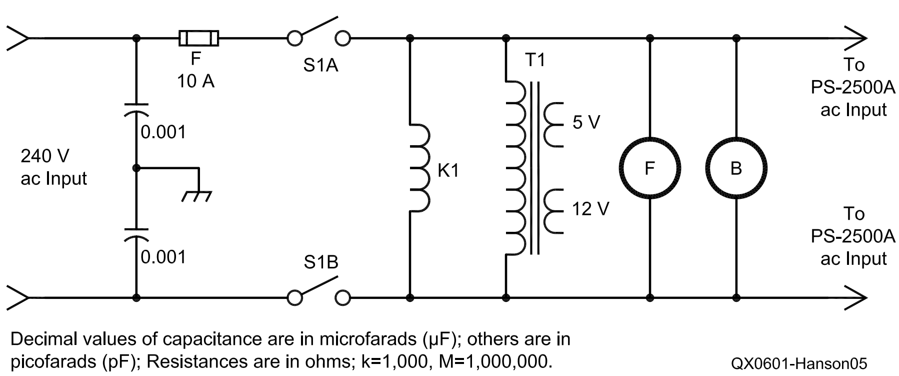

Fig 10—Schematic of power connections.

B—230 V 50 CFM blower.
F—230 V muffin fan.
K1—Omron DPDT 10 minute time delay relay.
S1—DPDT switch; 10 A at 240 V.
T1—Ameritron AL-1500 filament transformer, 230 V to 5 V at 10 A.

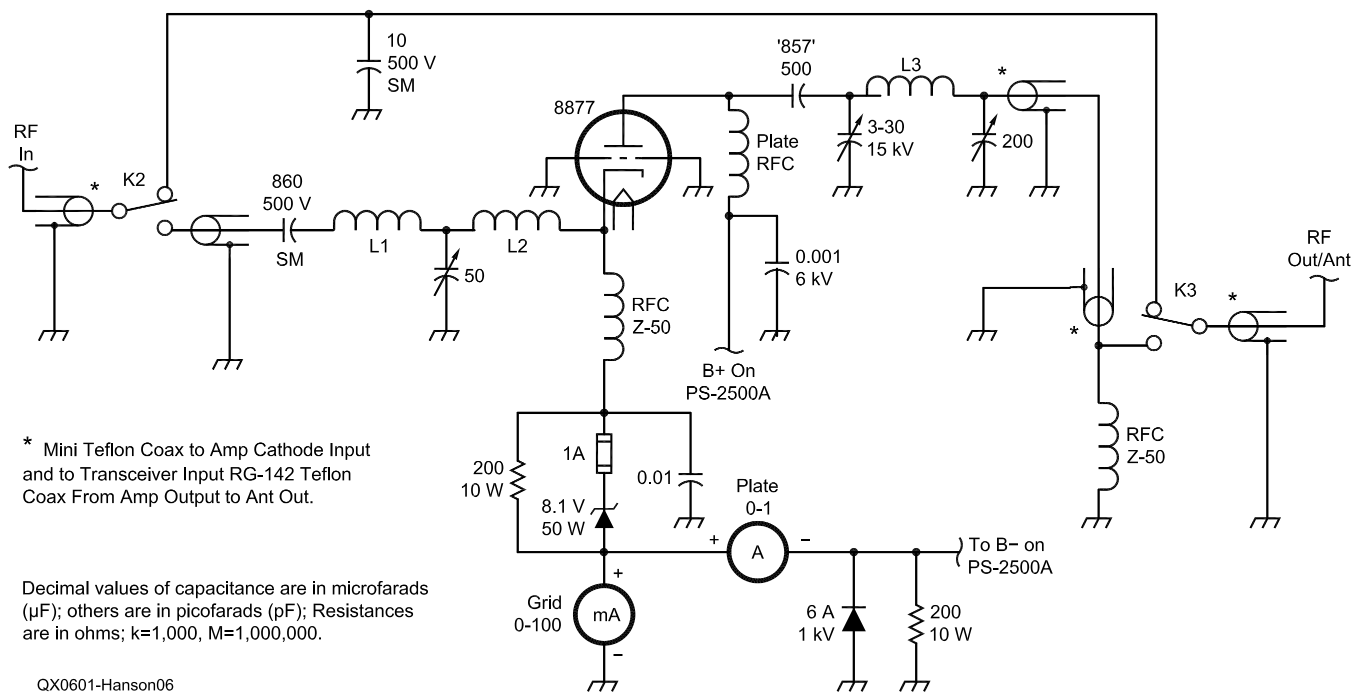

Fig 11—RF deck schematic. L1 and L2 are 9 turns 16 gauge, 1/2 inch diameter by 1 inch long. L3 is 4 turns, 3/16 inch tubing, silver plated 1 1/2 inch diameter by 3 inches long. The plate RFC is 12 turns 20 gauge Formvar close wound on a 1/2 inch teflon rod. The filament choke is 10 turns 14 gauge formvar each, bifilar wound on a 1/2 by 2 inch ferrite rod.

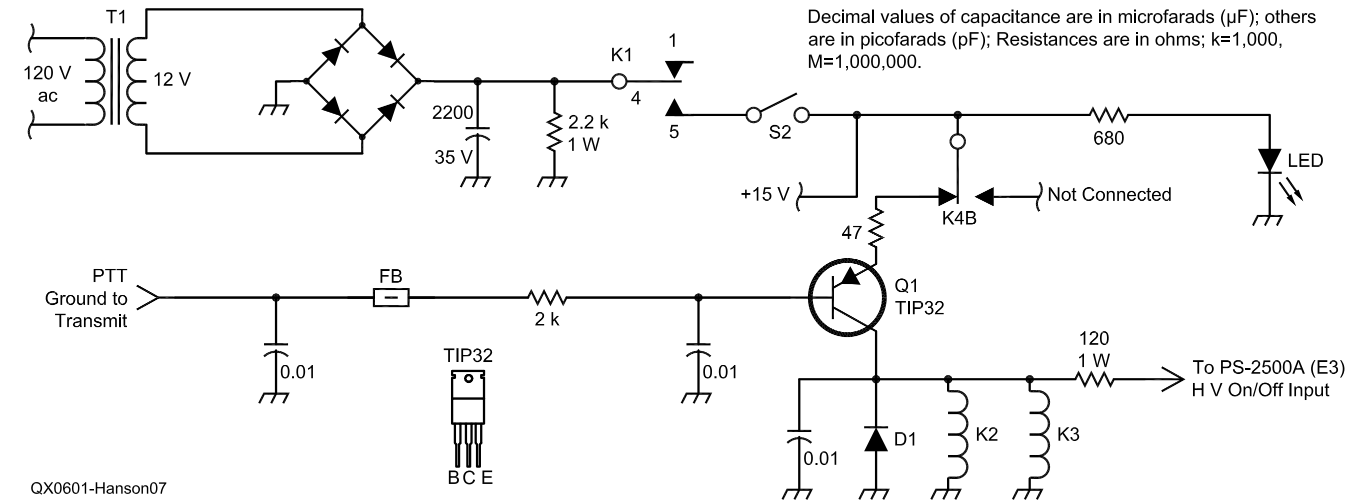

Fig 12—Schematic of control wiring. K2 and K3 are Schrack SPDT 12 V dc relays.

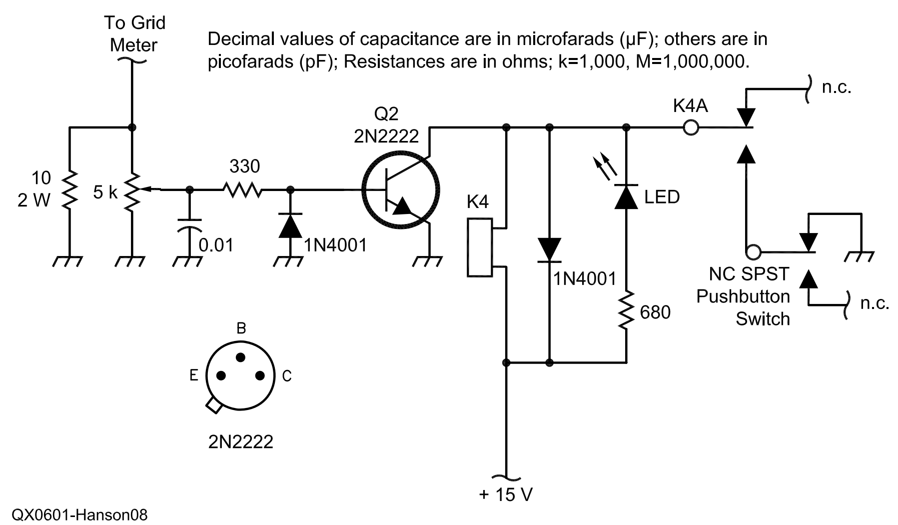

Fig 13—Schematic of optional grid circuit protection scheme. K4 is a DPDT 12 V dc relay

ear supplies have the B minus above ground by several hundred ohms to provide for metering. That is the option I chose. This means you need to remove the B minus jumper to ground. The negative terminal of the plate meter is connected to B minus through a 200 Ω, 10 W resistor in parallel with a 6 A 1 kV diode, both going to chassis ground. This affords both current measuring as well as protection for meters and power supply components.

I chose to "key" the supply on and off with +12 Vdc supplied by the PTT circuit.

Schematics and instructions for the power supply are not furnished here but are available for download from the manufacturer. An RF deck schematic is shown in Fig 11, control circuitry in Fig 12 and the optional grid protection circuitry is shown in Fig 13.

In closing, remember: *Failures on a mountaintop, or in some foreign country are easier to prevent than to repair* (ancient ham proverb).

Notes

[1]The PS-2500A may be obtained from: Watts Unlimited (Tim Hulick), 886 Brandon Lane, Schwenksville, PA 19473-2102; 610-764-9514; **www.wattsunlimited.com**.

[2]*2002 Proceedings of the Southeastern VHF Society*, p 254.

[3]The current metering subsystem is that shown in *The ARRL Handbook*, 2005 Edition, p 18.39.

Dick Hanson, K5AND, has been licensed since 1954. He holds a BA from the University of Texas and following 18 years with Hewlett-Packard in medical electronics has been the owner and CEO of Southern Staircase in Atlanta, Georgia. He has been building mostly VHF antennas and amplifiers for 30 years. He has lugged them to 19 DXpeditions, prompting the development described in this article. □□