8877 'Lite': A 50MHz, 20lb Travel Amp

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As those of you who do expeditions and mountain-top contesting can attest, carrying a kilowatt amp on your quest is *so* much fun. Over the years since 1987, I have created five travel amps, all for six metres. 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 a separate power supply, followed by a single 3CX800 with a built-in HV supply with a smaller (lighter) HV transformer.

The 8877 'Lite' amplifier in its carry-case.

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 'footprint' and weight but it still weighed in at 30 lbs minus the blower, plus 12 lbs for the luggage bag for a total weight of 42 lbs. I wanted a carry-on package that would weigh less than 30 lbs and, available wall voltage notwithstanding, an amp that would deliver 1500 watts under normal conditions.

Front view of the 8877 'Lite', showing the exhaust port on left, plate current meter top centre. Also shows the grid current meter at the centre, recessed power switch and amp in/out switch with LED indicator above. Top removable knob upper right is the plate tune; lower removable knob is the plate loading. Air intake for the power supply is on the bottom of the cabinet. The RF compartment is pressurised so that 95% of the air exhausts through the anode cooler and the rest exits through the cathode compartment.

Time for an extreme makeover?

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

Ever since seeing a prototype regulated HV switching supply in the Command Technologies booth at Dayton several years ago, I've dreamt about 'embedding' a HV switcher in an amp. Watts Unlimited was the first commercial entry into the HV 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 is as follows:

1. It is lightweight (10 lbs).
2. It has reasonable voltage regulation from idle to full-load (5-10%).
3. It is electrically 'quiet', although this does not matter much here since the supply is only 'on' during transmit.
4. It is capable of supplying enough power for 1.5KW RF output.

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 relay shorting out a 25k ohm 10 watt resistor - 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 several components from the amp.

'Cons' to keep in mind include:

1. The supply must not be turned on without a load. To do so would be to guarantee a failure of the output caps as the resulting HV would soar over their 4kV rating. The manufacturer recommends a minimum idle current of 150-250 mA at turn-on. So if you're going to use a zener for the operating bias, you pre-select a zener that will make the tube draw 150 mA or so at idle.

2. 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 5-12VDC 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.

Rear view, showing RF input and output connectors at bottom left and top left. Also shows the mounting flange for the blower, cathode compartment air exhaust (under blower flange), AC power connector for blower and fan upper center, fuse, RCA PTT and AC mains connector, hole for muffin fan at far right. Both openings are 'screened' with stainless screening.

Design criteria for this amp

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 amp 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. The other tube considered was my personal favourites the 3CX800. But for this application, the single 8877 worked best with 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 volts. At a full load of 850 mA, the anode voltage drops to 3 kV. The power supply remains cool and electrically quiet while 'dormant' even though 240VAC is present. When the PTT is activated, the supply goes from zero volts to full output in a few milliseconds.

Other features of this amp are:

1. A relatively small box (less blower): 6.5'H by 13.5'W by 12'D.

2. Light weight: 20 lbs, including built-in power supply.

3. No protrusions from the cabinet to break in transit:

a. no knobs; screwdriver adjust for plate and load caps

b. AC line entrance with flush plug and socket

c. plate and grid meters are protected behind front panel

4. A three-minute time delay to hold off PTT until cathode warms up;

5. Built-in RF input/output relay switching;

6. Vacuum plate cap and physically small meters to help 'shrink' the cabinet;

7. Fits inside a rolling carry-on Travel Pro bag (weight 8 lbs); 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!

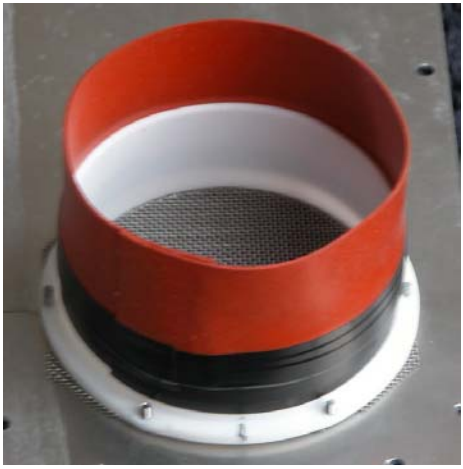
8. Should be capable of 'high duty modes' (like JT65) for EME work (an extra exhaust fan over the tube).

9. Since the power supply has two built-in shut-down circuits, either of which takes the supply off line, you must have a means of also taking the amp off line to keep the grid from trying to draw lots of current in the absence of anode voltage. Hence, a grid-trip circuit is included.

This amp will not win any beauty contests, but it will be rugged!

Building the amp

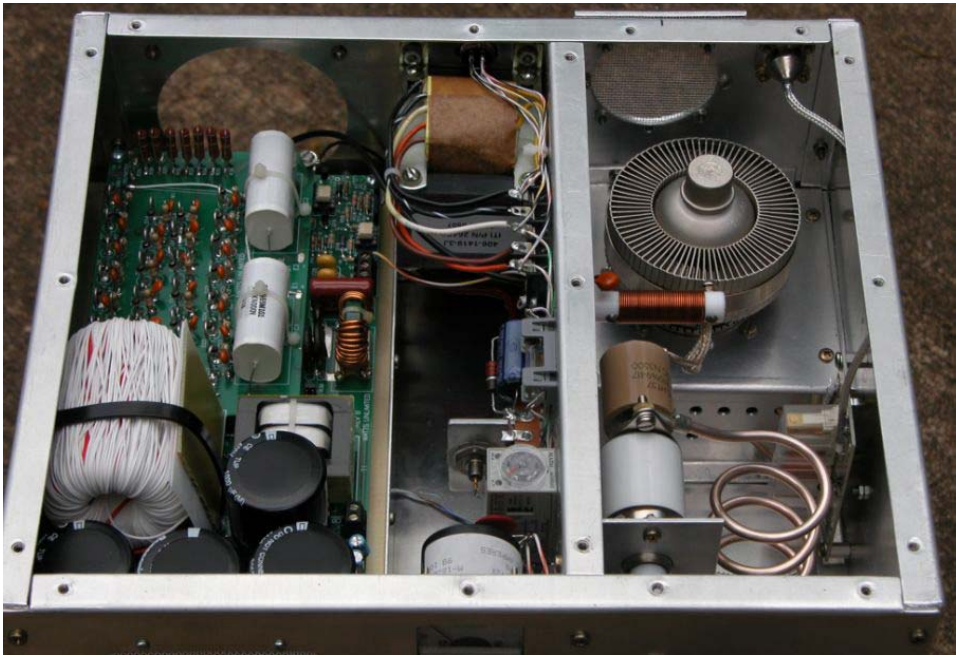
1. For me, the hardest part of a project is planning the metal work - which of course is dictated here not only by the size of the components but also by the airline size limitations for 'carry-on baggage'. Charlie Byers of Byers Chassis supplied the chassis and its 'innards'. I had some more metal work done by a local machine shop and I used embedded captive nuts for cabinet assembly rather than gambling on my fat fingers



The teflon chimney with rubber extension, for pressurising the anode compartment.

2. 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 ¼' shafts and then milled the ends of the shaft 'stubs' to resemble a flat screwdriver blade. 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 cathode tuning capacitor is also a screwdriver adjustment and once set, it will hold tuning over at least 1 MHz.

3. This amp uses a conventional pi-circuit instead of my normal pi-L circuit in order to save a little more space. I always carry a high-power ICE six meter



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

filter, so no worries about 2nd harmonic rejection. The blocking cap is an '857' type, rated at 15kV and a 'lot' of current.

4. The RF input/output relay board is same one I have been using for a number of years now. The SPDT Schrack relays have very robust contacts and the amp off-line VSWR may be 'tuned out' using the little thru-line capacitor to ground trick mentioned in an earlier article.

5. 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, an eternity when the band is open and the amp is warming up...

6. The power cord set is a heavy duty IEC arrangement featuring a standard

Larger view of tank circuit, showing silver-plated tank coil, 3-30 vacuum variable, 857 blocking cap, RF plate choke and almost buried at the bottom, the 200 pf loading cap.

three-prong male chassis mount connector mated to a three-wire, number 12 AWG power cord about 8' long. The plug end is left un-terminated so that you

can put on whichever male plug may be required for the country you're visiting. Again, this 'connector' approach on the amp 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 10A at 250VAC. The filament and control voltage 'combo' transformer is an Ameritron unit, PN 406-1419-3J, $49.95.

7. The plate RF choke is wound on a ½ ' Teflon rod, using 42 turns of #20 Formvar insulated copper wire. The bifilar filament choke is ten turns of #14 Formvar insulated copper wire wound on a 2' long by ½ ' diameter ferrite rod.

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

9. Tripplett 120-G meters are used for the plate and grid metering since they are physically small and very high quality. Because they are mounted **behind** the front panel, they are pretty well protected from abuse. The grid meter is a 100 mA unit and the plate meter is a 1.5 amp unit.

10. Grid over-current protection is provided by Q2 and its associated circuitry. The 5k pot in the circuit allows the trip current to be set in the range of 40 – 150mA, which is adequate for the 8877. When the pre-set current is reached, Q2 conducts, which in turn closes K4. One set of contacts locks the relay 'on' and turns on the 'trip' LED; the other set of contacts opens the +15 volt control bus to the PTT circuit, thus taking the amp off-line until the over-current condition has been resolved. Depressing the normally closed pushbutton switch resets the trip circuit.

Another view of RF deck, showing the 8877. Also shows the anode clamp and input/output relay switching board, featuring the Schrack relays. Also note the Teflon RG-142 coax for the output which will handle the 1.5 kW without meltdown! Also shown is part of the control circuitry: Omron time delay relay and Tripplett 120G series plate and grid meters. The fuse at the centre is the 1 amp cathode circuit fuse.

11. To pre-set the grid-trip value, apply +5VDC temporarily to the junction of the grid and plate current meters through a 500 ohm pot. Adjust the pot for some not-to-exceed value of grid current, say 100ma for example. With the pot set at maximum, gradually turn it towards minimum until K2 latches and the 'trip' LED illuminates.

Specifications

No surprises here:

1. With 40-50 watts of drive, the amp will put out 1500 watts with 2500 watts input.

2. The anode voltage is about 3000 volts under a load of 850 mA. Grid current runs between 40-60 mA with this loading and anode voltage.

3. If you have an MFJ 259, you can do all your preliminary tuning before applying high voltage. Getting the cath-

ode and tank circuits 'in the ballpark' before applying drive is always a good feeling.

Installation of the PS-2500A supply

The good news is: very few connections are required for this unit. The sobering news is: 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 regarding the following points:

1. AC connections, including neutral
2. B minus
3. HV turn on-off
4. B plus connection
5. Metering
6. Jumpering

The supply factory default wiring means 240VAC mains; it also means the B minus connection is tied to chassis ground. Most linear supplies have the B minus 'floated' above ground several hundred ohms for metering purposes, which 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, then this point goes to chassis ground thru a 200 ohm 10 watt resistor in parallel with a 6 amp 1kV diode. This affords both current measuring as well as protection for meters and PS components.

I likewise chose to turn the supply 'on & off' with +12VDC supplied thru the PTT circuit.

Schematics and instructions for the power supply are not furnished here but are available for download from the manufacturer.

The PS-2500A high voltage switching power supply. The white thing at top left is the high voltage transformer; the 50 ohm, 50 watt glitch resistor* is upper right. The two HV output caps are centre right; total output 'C' is 0.2 mF at 4000 VDC. *Note: **the glitch resistor is not really necessary with this supply since it features an automatic shut-down circuit which activates if the supply tries to draw more than 19A. Still, old habits die slowly for me; it can't hurt to have the extra protection of the glitch.**

In closing

Remember: failures on a mountaintop or in some foreign country are easier to prevent than to repair (ancient ham proverb).

If anyone has any questions on this project, please phone or e-mail.

One postscript is that it would be possible to shrink the cabinet one more inch in height. If you eliminate the 1' tall fan mounted below the PS heat sink and change the air flow (and vents) from front to back, you could wind up with a cabinet only 5.5' high! You pretty much need all of the 13.5' of width and all of the 12' of front-to-back depth, though.

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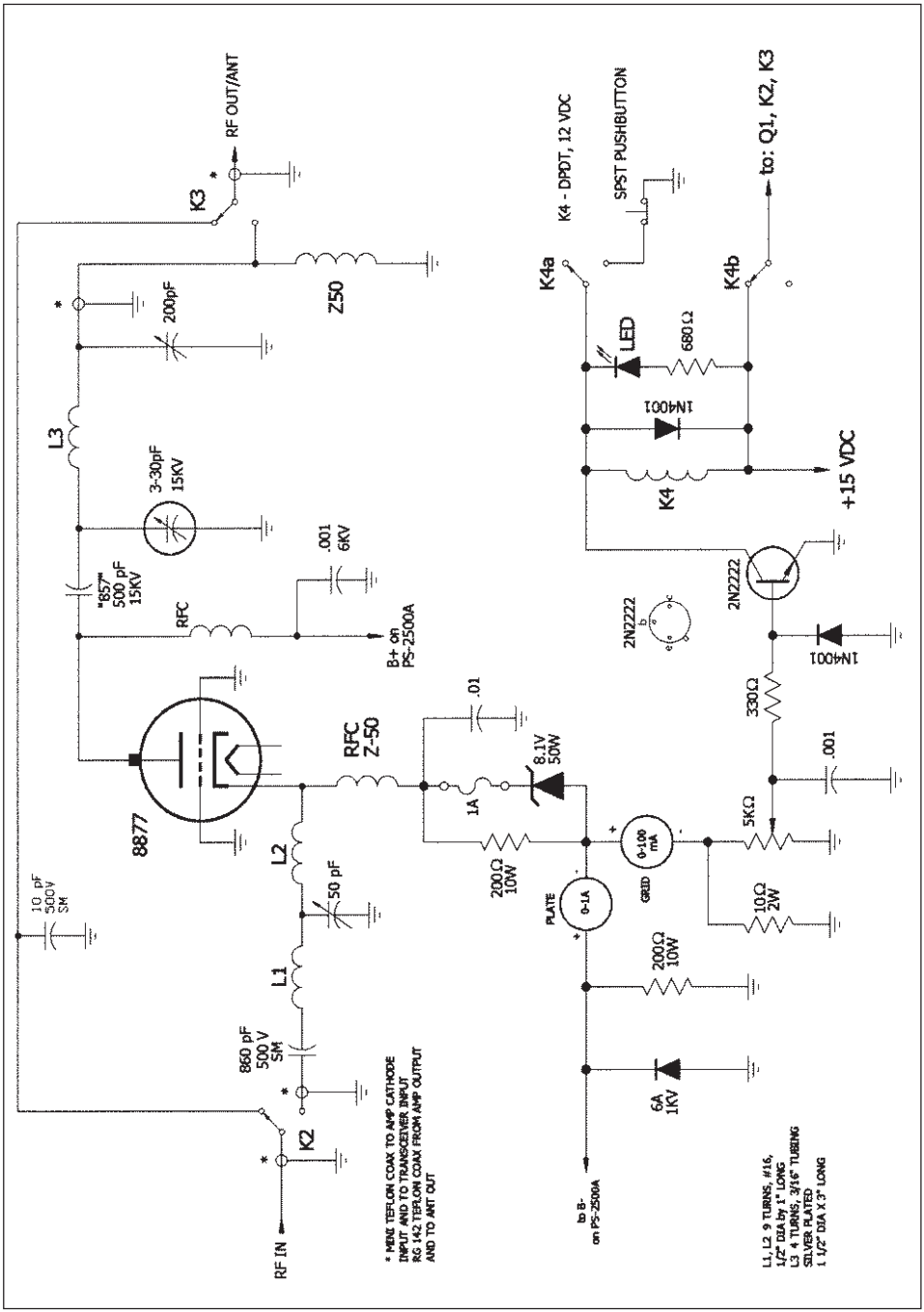
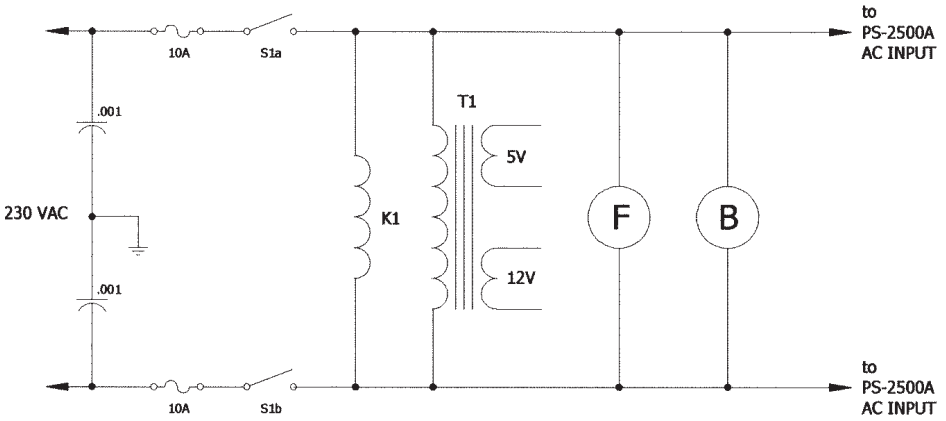
The PS-2500A may be obtained from Watts Unlimited (Tim Hulick), 886 Brandon Lane, Schwenksville, PA 19473-2102; tel: +1 610-764-9514; email: *www.wattsunlimited.com*



The 8877 amp main schematic.

POWER WIRING



K1 Omron DPDT 10 minute time delay relay
T1 Special transformer: 230 VAC primary, 5 V @ 10 amp sec #1; 12 V @ 1 amp sec #2
B 230 V 50 CFM Blower
F 230 V muffin fan
S1 DPDT switch; 10 amps at 240 VAC

CONTROL WIRING