

Buying an HF High Power Amplifier:

-What to consider first-

Two Parts:

1. Some Trade-offs:

- **New vs. Used**
- **Tube vs. Solid State**

2. A Troubleshooting Example

- My article on eHam “The Big Step to 1.5Kw”
(www.eham.net/articles/21381)

- Overview discussion due to time constraint

Why Do You Want The Power?

- DX chasing
- Contesting
- Reliable communications during poor conditions
 - Daily and seasonal variations
 - Sunspot cycle
 - You may not need the amp in a few years
- **General rule:** Upgrade antennas first and amps last
 - “If you can’t hear’em, you can’t work’em”
 - “A big amp won’t make you a big gun”

What To Buy

- Selection criteria
 - Maximum power
 - Best Bang/Buck
 - I like “\$/watt” (with a max power of 1500 watts out)
 - Reliability
 - New vs Used
 - Tube vs Solid State

Used Amplifiers (Tube Types)

- Examples (watts are PEP output):
 - Yaseu FL-2100B \$350+
 - Heathkit SB200 (600w) \$400+
 - Heathkit SB220 (1Kw+) \$800+
 - Drake L4 (1 Kw) \$800+
 - Collins 30L1 (500w) \$1000+
 - Rockwell/Collins HF-80 (45Kw) over \$8000
 - Others (500w to ???w) \$250 to \$\$\$\$+
 - Many older amps are power supply limited
 - Upgrading to bigger tubes won't get you much more output
 - ***Avoid "CB" amps***

Used Amplifiers (Tube Types) - continued

- Known design limitations/problems
 - Many popular amps are over 30 years old
 - Designs over 40 years old
 - Parasitic instability => catastrophic tube & part destruction
 - Soft start-up circuitry
 - Exciter power level (min & max)
 - Too much drive => splatter and/or tube failure
 - ALC may not be a good way to control drive level
 - T/R switching interface circuitry (100+ vdc and/or high current)
 - CW keying interface circuitry
 - Meter protection circuitry

Used Amplifiers (Tube Types) - continued

- Known design limitations/problems - continued
 - Filament voltage (tube life vs. output power)
 - Most old tubes should be “de-gassed” before HV applied
 - “Gassy” tubes can catastrophically short on power up
 - Even applies to NOS tubes
 - Usually requires a high power variac
 - Modification info & kits available for most amps:
 - Rich Measures (www.somis.org/)
 - Harbach (www.harbachelectronics.com/)
 - Many other sites on the Internet

Used Amplifiers (Tube Types) - continued

- Replacement parts may be hard to find and/or expensive
 - Power transformers:
 - Can cost >\$400+ if you can find one
 - ALPHA charges \$750
 - Electrolytic capacitors (\$150+)
 - Replacement tubes:
 - Multi-tube amps usually require matched tubes (RF Parts does this)
 - U.S. made tubes becoming scarce & are expensive
 - “Sweep” tubes (I recommend avoiding amps that use these tubes)
 - 3CX1200A7 (~\$1100 new)
 - 8877/3CX1500 (~\$1100 new, but medical “pulls” available for ~\$250)
 - Foreign mfgs may be the only option (cheaper, but quality=?)
 - 3-500Z (~\$170 for Chinese tubes)
 - 572B (~\$100/matched pair for Russian tubes)
 - 8877 (~\$600)
 - GU-xx (Russian)

Final cost of a used tube type amp can be **1.5 to >2x** the original purchase \$

1Kw CB Sweep Tube Amplifier



Used Amplifiers (Solid State Types)

- Older transistor amps not as well protected as modern amps
 - Transistor amps **VERY** limited on allowable load SWR
 - Frequently include an internal automatic antenna tuner
 - **Prone to blow out transistors in final stage**
 - Transmit into wrong antenna at full power
 - Hot switching
 - Computer glitch (stations with computer control)
 - Defective antenna relay
 - Replacement transistors may not be available or big \$\$\$\$
 - Power supply spikes
- Cooling is also a big design challenge compared to tube amps
- Power supply needed for 1000 watts out (2 Kw input):
 - 12 vdc @ **160+ amps**
 - 50 vdc @ 50 amps
 - A good power supply can cost as much as the RF amp

New Amplifiers (Tube Types)

	<u>Cost</u>	<u>\$/watt</u>	<u>eHam Rating</u>
• Ameritron	\$700-3000	1.2-1.9	4.4-5.0
– AL-82 (1500w)	\$2300	1.5	4.8
• QRO HF-2500DX	\$4100	2.7	4.9
• Commander HF-2500	\$3500	2.3	5.0
• Acom	\$5500	3.7	5.0
• Alpha 9500	\$10000	6.0	4.4

New Amplifiers (Solid State Types)

	<u>Cost</u>	<u>\$/watt</u>	<u>eHam Rating</u>
• Ameritron ALS-600	\$1200	2.0	4.0
• Yaseu Quadra (1Kw)	\$4000	4.0	4.4
• Icom PW-1 (1Kw)	\$4700	4.7	4.6
• Tokyo HL-2.5KFX(1.5Kw)	\$6000	4.0	5.0
• Newer SS amps:			
– Improved reliability, but still not as rugged as tube amps			
• Still hear stories about output transistor failures for unknown reasons			
• Recent Quadra repair was over \$750 for transistors and took >3 months			
– Cost 2-3x what a comparable tube amp would cost			
• Partly due to the internal automatic antenna tuner			

Other Considerations

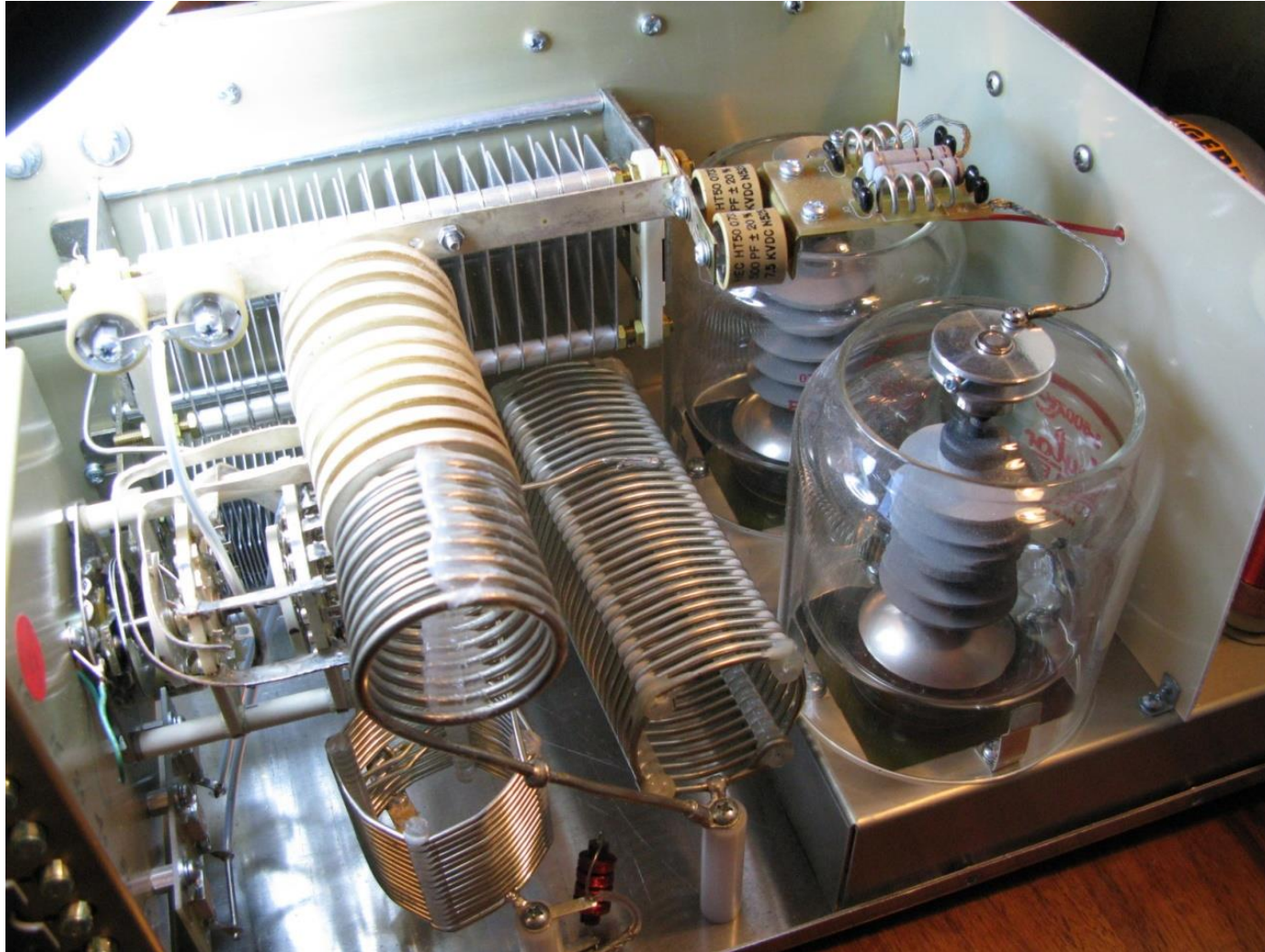
- Shipping expense:
 - Weight: 70-100 lbs
 - May need to partially disassemble and pack into several boxes
 - AL-82 requires 3 boxes
- AC power:
 - 240VAC is advisable for all amps over 500 watts output
 - 240VAC required with some amps
- Can your coax, tuners, RF switches, antennas, etc. handle the increased power?
- RFI:
 - TV, sound system, telephone, computer, alarm system, ham radio interfaces, ...
 - Neighbors and especially the wife

Other Considerations - continued

- Safety:
 - **Lethal voltages** in tube amps!!
 - **ARC welding currents** in SS amps
 - High power RF signals can be a health concern:
 - ***FCC requirements apply to every RF emitting device in the US***
 - Both “controlled” and “uncontrolled” environments
 - Must complete the FCC “***RF Environmental Evaluation***” if RF power ***into the antenna*** exceeds:
 - » 500 watts (160-40 M)
 - » 50 watts (10 M)

A Troubleshooting Story (New Ameritron AL-82)

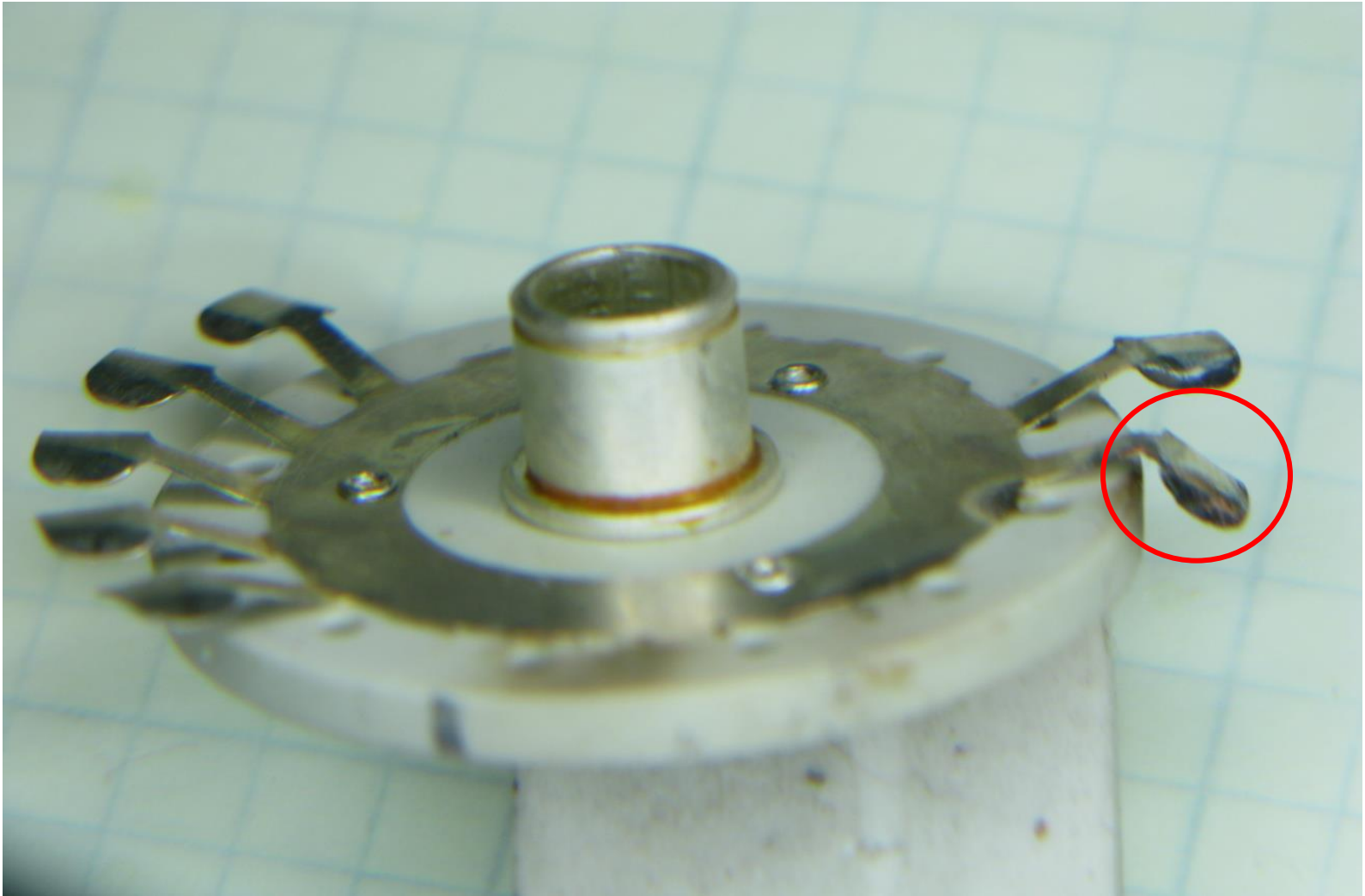
AL-82



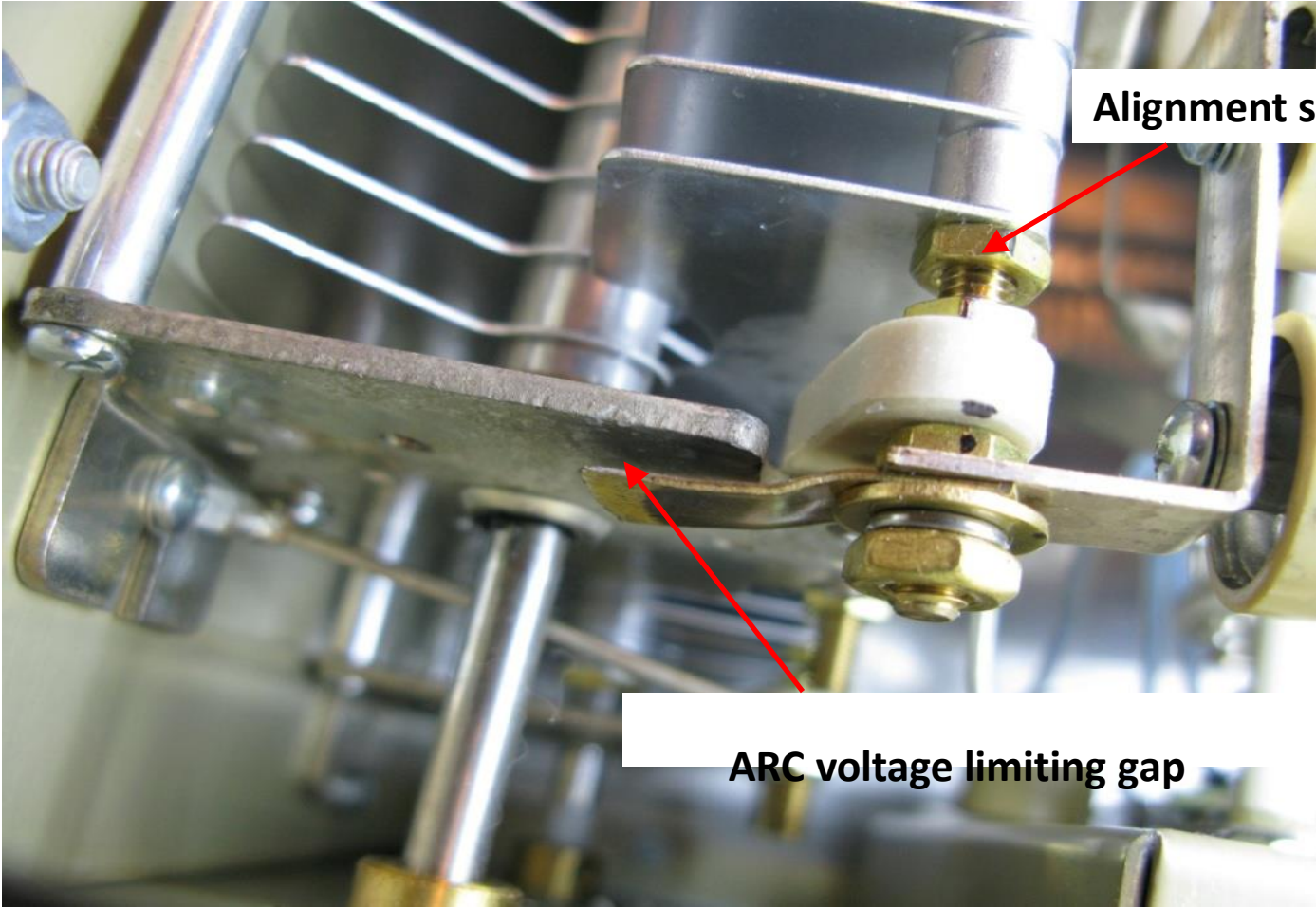
Initial Problems and Interesting Observations

- Operational Problems:
 - *Persistent arcing in the output tank*
 - *RFI*
 - *Low output power (<1Kw on some bands)*
- Observations:
 - Loose hardware and solder flash
 - Cracked wafer on bandswitch
 - Bent tab on bandswitch
 - Mis-aligned plate tuning capacitor
 - Improperly adjusted arc voltage limiter gap
 - High input SWR on all bands
 - Internal power meter readings very inaccurate
 - Plate tuning capacitor not in correct position after tune-up

Defective Bandswitch (Bent tab)



Tuning Capacitor and Arc Voltage Limiter



Alignment screw

ARC voltage limiting gap

Problems & Observations - continued

- **Low output power:**
 - Max out = 1 KW, even with 105 watts of drive power
 - The amplifier is specified to deliver 1500 watts out with 100 watts drive.
 - Incorrect setting for the plate capacitor
- **Input SWR:**
 - Input SWR was between 1.5 and 2.0:1 on all bands (no resonance)
 - The amplifier is specified to have a minimum input SWR for each band of less than 1.2:1 at resonance.
- **Amplifier's "Output Power" meter readings:**
 - 1500 watts into 50 ohm dummy load
 - 2200 watts into dipole
 - 1000 watts into vertical

Problems & Observations - continued

- **Arcing Symptoms:**

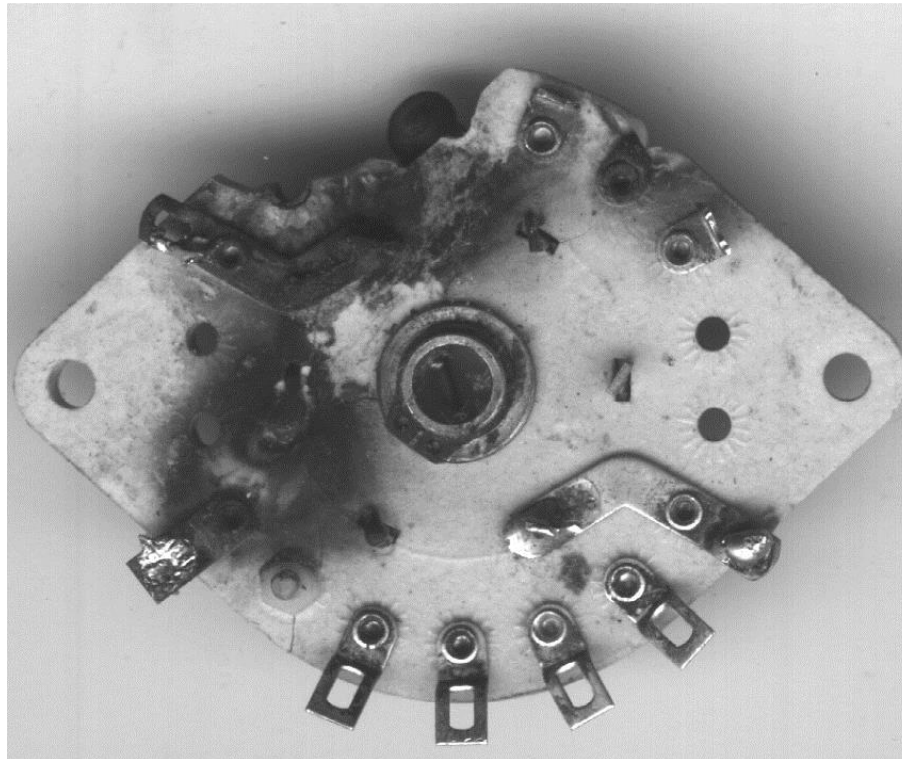
- A loud hissing sound from inside the amplifier
- Both plate and grid current meter reading would abruptly **drop** nearly to zero
- The symptoms didn't change with load type.
- I never encountered arcing at output power levels below ~700 watts.
- A carbon had formed on one of the bandswitch wafers (Figure 3)
 - Formed after only about 20 short duration arcing events

Figure 3: Arced Bandswitch in My Amplifier



ARCing (the end result)

Figure 5: The Final Result (Output Tank Bandswitch on the Measure's Website)



Persistent ARCing can lead to serious consequences

Problems & Observations - continued

- **RFI:**

- RF interference when the amplifier output power was increased above the 500 watt level:

- Audio and TV equipment
 - Telephones
 - Digitally controlled radio equipment
 - Computers
 - Unpowered burglar alarm system

- RF in the shack

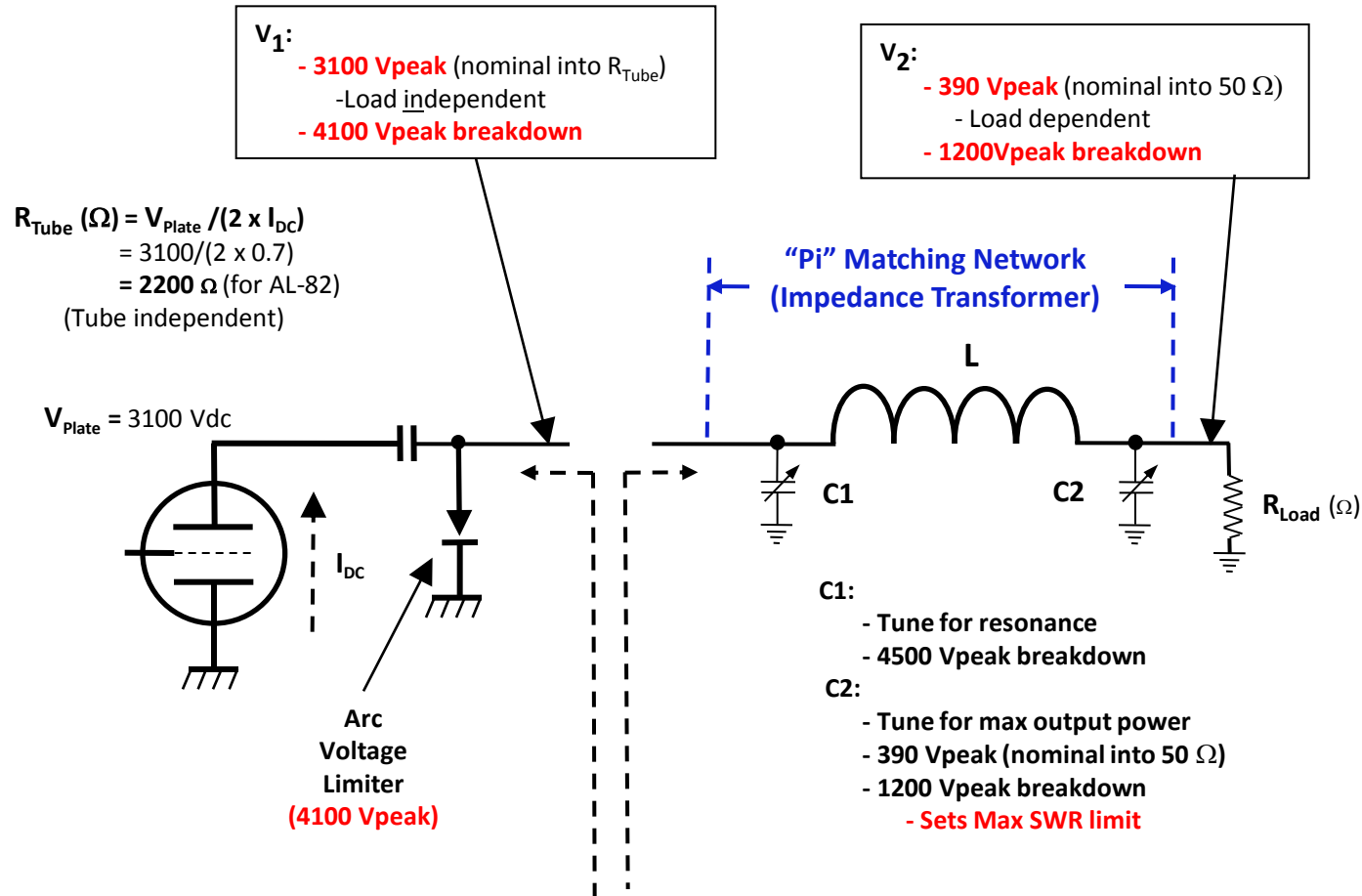
- “Hot” mic
 - Feedback into the exciter
 - Distorted transmit audio (unintelligible in severe cases)
 - **Transmitter would not turn off (not using VOX!)**

Solutions

- Fixed all workmanship problems first
- Addressed Arcing next:
 - Two technical camps:
 - Parasitic oscillations
 - Improper loading on the amplifier tube(s)
 - Parasitic oscillations usually cause one/more of:
 - Plate and/or grid currents peg their respective meters
 - Blown fuses
 - One or more components (diodes, resistors, tubes, etc) shorted or open
 - Erratic plate and grid current fluctuations during tune up

Arcing => Being Caused by Improper Loading

(Probably due to defective bandswitch)

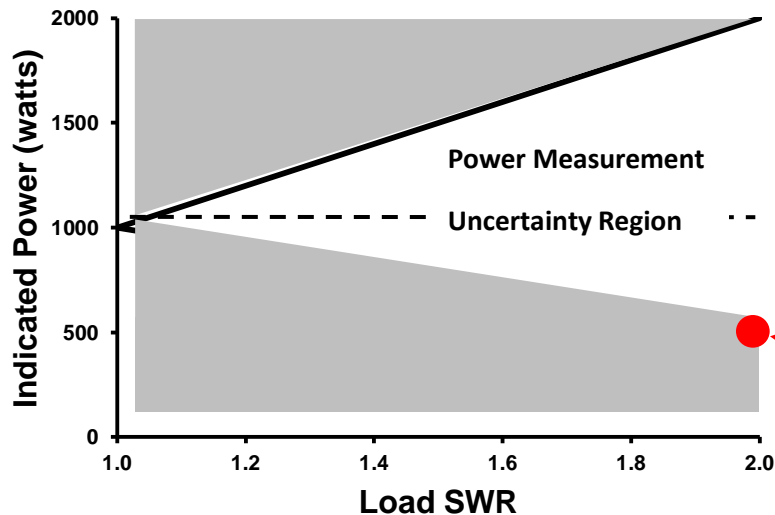


To achieve max output power, must do an "impedance match"
 (Make R_{Load} look like R_{Tube} to the tube)

No ARCing has occurred since the defective bandswitch was replaced

Solutions - continued

- **Low output power:**
 - The defective bandswitch was also contributing to the low output power problem
 - Amplifier input SWR was causing my transmitter to partially shut down due to activation of the SWR protection circuit
- **AL-82 Power Meter accuracy:**
 - The amplifier “power” meter is only measuring the **voltage** at the antenna output, and converting that **voltage** reading to a power reading on the meter **assuming a purely resistive 50 ohm load** (Figure 4)



This “power meter” is little more than a “tuning indicator”

Measured 440 watts into 25 Ω load

Solutions - continued

- **RFI:**

- I found it necessary to incorporate a number of the fixes per the

- [ARRL RFI Book Vol 2:](#)

- Improved RF filters on AC lines
 - Significantly improved station RF grounding
 - Single point ground
 - Counterpoise with ground rods
 - Added RF “common mode” chokes in signal cables and AC power cords
 - Relocation of some antennas

- Adding the recommended AC power line common mode choke to my sub-woofer audio amplifier caused it to catastrophically fail

- Blew out all of the power FET's

Success (Almost)

- After successful trial runs at 1.5 Kw into a 50 ohm dummy load with no arcing, I decided to try loading into my antennas:
 - My commercial multi-band vertical failed after about a minute at 1.5 Kw
 - The manufacturer rates this antenna for “full legal limit”
 - I was told on the phone not exceed **500 watts CW**
 - The manufacturer uses **500 volt silver mica caps** to tune the antenna
 - My trap dipole failed after two minutes at 1.5 Kw
 - This time, it was a commercial balun that had failed
 - The manufacturer rates this balun for “2 Kw PEP”
 - After replacing the balun, the amp failed again. This time it blew a 0.5 inch diameter hole through one of the commercial 40 M traps (these traps are rated for “2 Kw PEP”). I made my own high power traps from PVC, doorknob caps, and 600 volt wire.

“P.E.P.” is a **voltage** rating

Homebrew Trap



Success (Finally!!)

- I can now put 1.5 Kw into my dipole on all bands for several minutes without arcing or other problems
- I can easily find the maximum output power point
- The plate tuning capacitor ends up in the designated position on all bands
- The amplifier is also very tolerant of mis-tuning of both the plate and load capacitors
 - While running 1.5 Kw into the antenna (which has a 1.6:1 SWR), ***I can de-tune either/both the plate and load capacitors enough to drop the output power by 500 watts with no signs of arcing or other unusual behavior.***