ACØC SB200 SLEEPER

Xtreme Conversion

SB200 STOCK CONFIGURATION

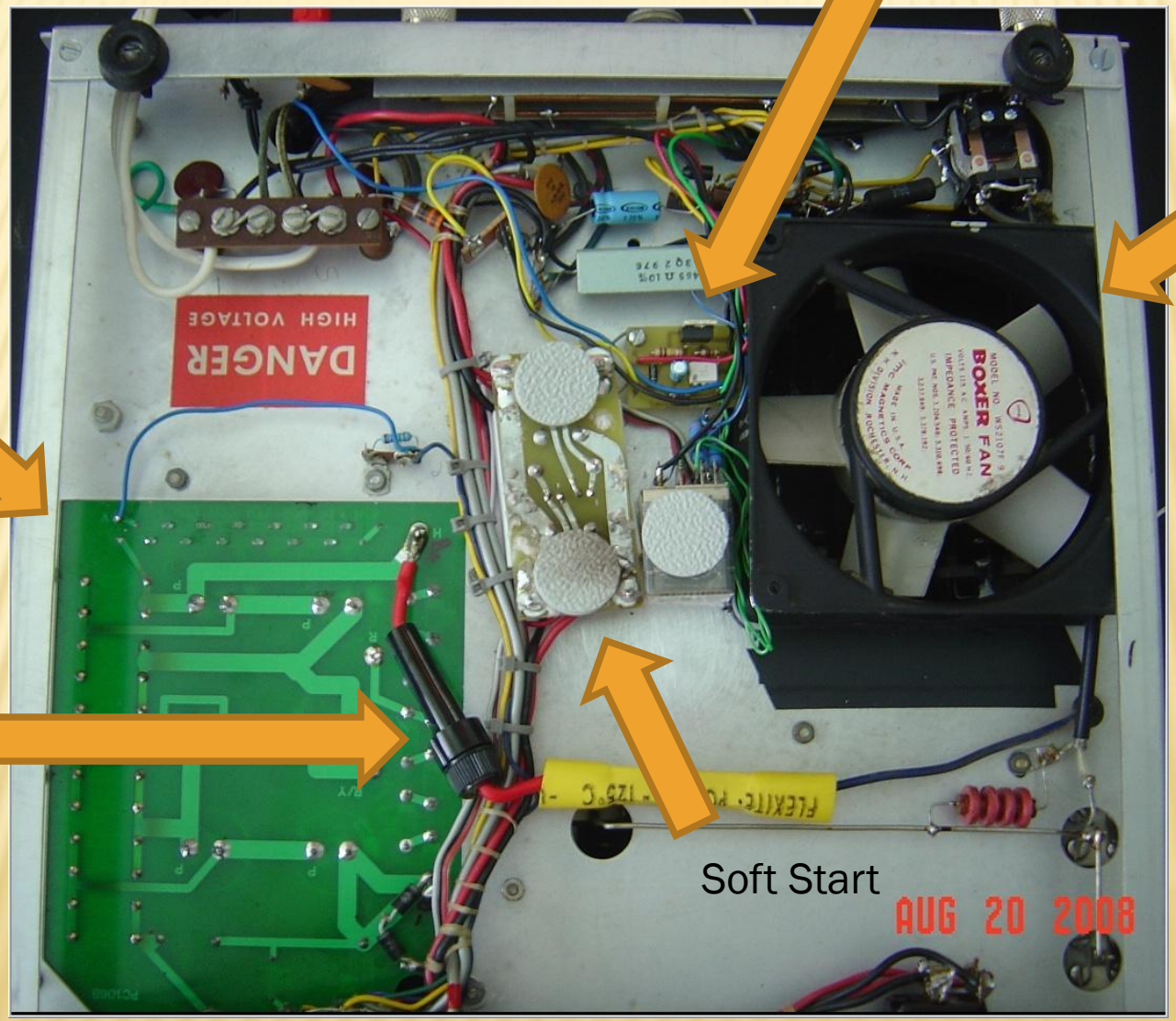
- 2x572B glass triodes – 320W plate disipation
- 2400v idle; 2100v loaded @ 500ma
- 500w typical output (800w on fresh tubes)
- 80-10m operation

STOCK SB200 RF DECK

INITIAL MODS

- Power Supply Replacement
  - Larger diodes, caps, matched bleeders
  - Other electrolytics
- Replaced T/R relay
- Added soft-start circuit
- Replaced fan with 120mm 80 CFM muffin
- Blackened RF compartment walls
- Dual speed fan
- Basic glitch protection
  - Fused anode + resistor
  - Diode clamps on B-/gnd and across meter

INITIAL MODS



INITIAL RESULTS

- Original? tubes - 560w output max on 80m
- Good signal quality reports
- Problems
  - Tune control - very sensitive
  - Input match problems on most bands
  - Loud relay
  - Glitching
  - Safe operation point for RTTY?

MODS – PART 2

- Replaced stock panel with black-face
- Vernier reduction drive added to tune control
- Replaced grid resistors
- New tubes – China sourced
- Meter backlight replaced with blue/white LED array

RCA -> SO239 RF INPUT

HARBAUGH PS BOARD & METER BACKLIGHT

BLACK PANEL

VERNIER REDUCTION DRIVE MOD

RESULTS – PART 2

- New tubes – 850w PO 80m
- 800w → 500w after 20 hours operation time
- Glitch event → anode fuse blows → ↑ grid current
- Nice platform for 1970 → basic shortcomings

SB200 – OEM DESIGN PROBLEMS

- 572b is a fine SSB tube – other mode challanged
- No glitch protection
- ↓ Ip → ↑ Z → insufficient load cap
- No 160m
- No QSK
- No modern fault condition reporting
- No Ip or Ig over-current protection
- RF input - RCA jack

Next Step

LOOKING FOR A BETTER SOLUTION

SB200 SLEEPER - GOALS

- Modern (?) ceramic/metal tubes
- 1000w output under RTTY duty-cycle
- Full high-speed QSK capability
- 160m coverage
- Silent operation at idle; noise to match loading
- Full fault condition monitoring & reporting
- Modern cosmetic look – while preserving original “lines” – retro feel

572B VS GI7B

Metric	2x572b	1xGI7b
Heater	6.3v	12.6v
Plate V	2100v	2100v
Plate I	500ma	500ma
Anode dis	320w	350w
Power Out	500w	525w
Const	Glass	Met/Cer
Cost	$80/pr	$40/ea
Supply	China only	Russian Mil NOS
AC0C serv lifetime	25 hours	???

EYES WIDE OPEN – GI7B DISADVANTAGES

- No performance curves available under typical ham application parameters
- Very little test data and engineering work published
- Supply longevity ???

USE ONE - OR - TWO TUBES?

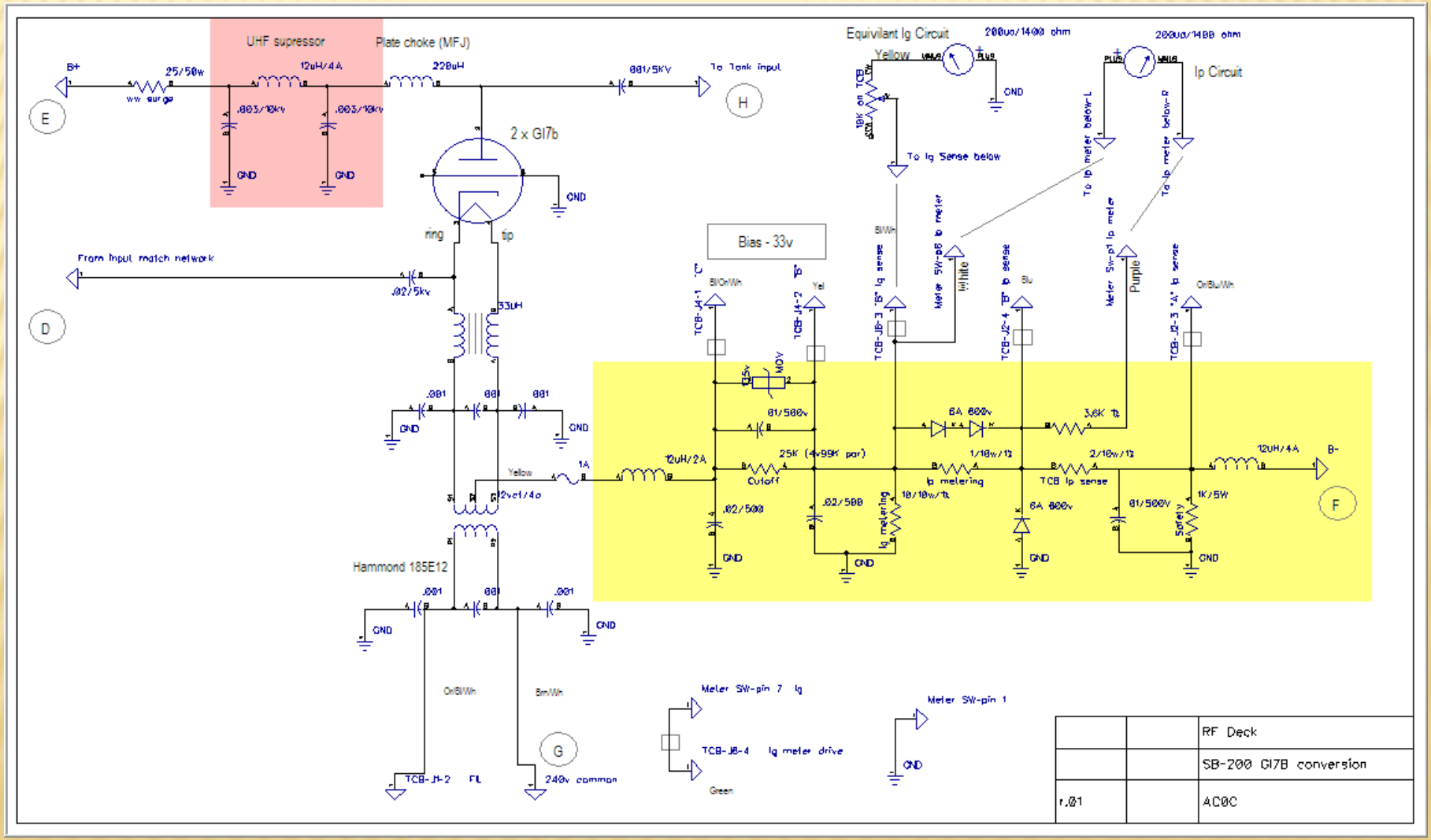
- Worst case mode is RTTY
- 2100v * 500ma = 1050w input (same condx as 572b pair)
- At 55% efficiency & 50w drive, plate disipation = 522w
- 522w worst case vs 350w = fast tube death
- 522w worst case vs 700w = nirvana
- CONCLUSION: Two tubes are needed to fully utilize the **stock power supply** capacity

2XGI7B SB200 – PROOF OF CONCEPT

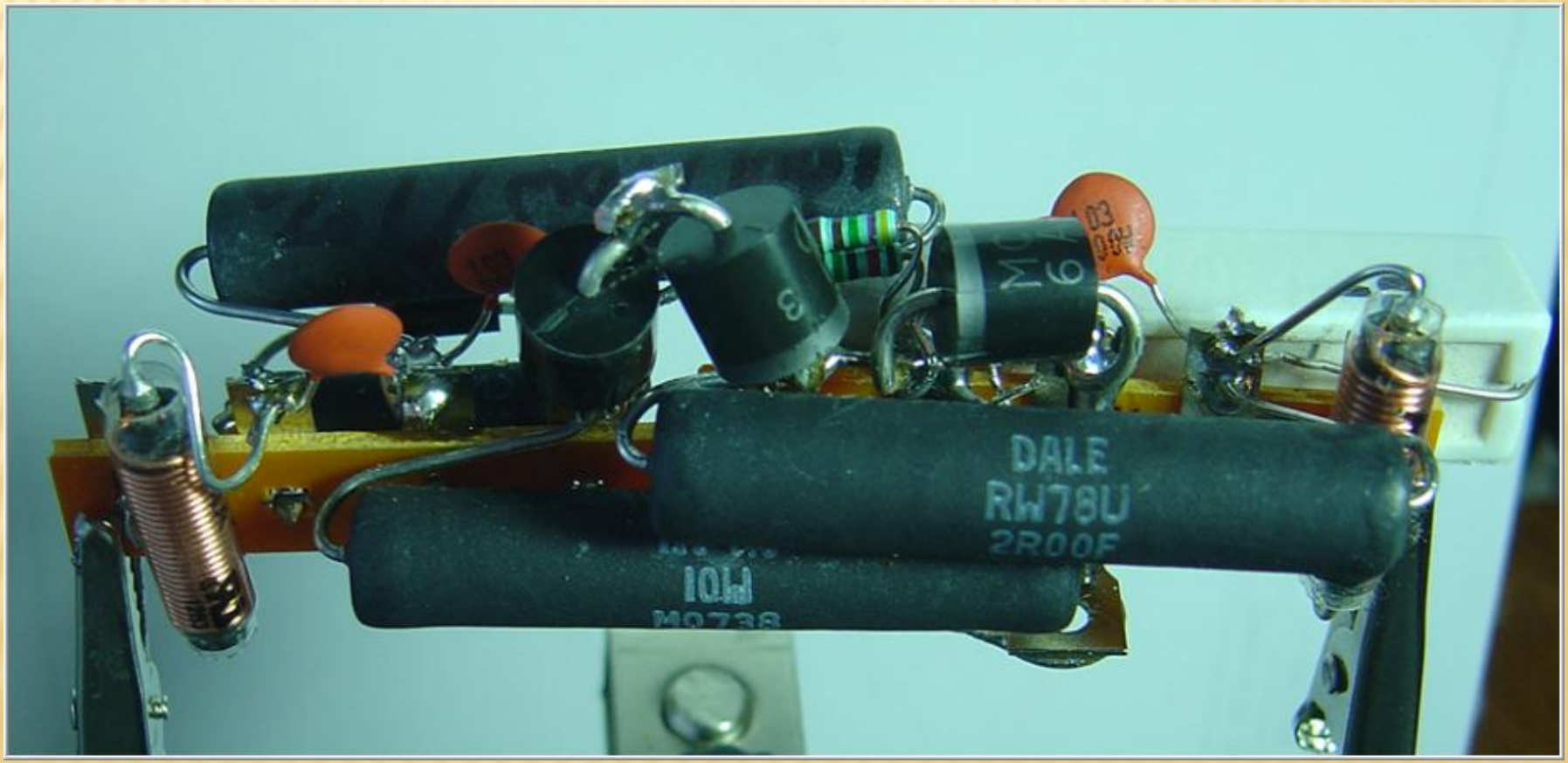
GI7B – MINIMUM MODS REQUIRED

- Replace tubes / sockets
- Bypass input matching network
- Add 37v bias board & relay switching
- Add 12.6v filament transformer
- Replace cathode circuitry
- Adjust metering
- Good news: B+ supply OK – 2050v @ 0.7A +

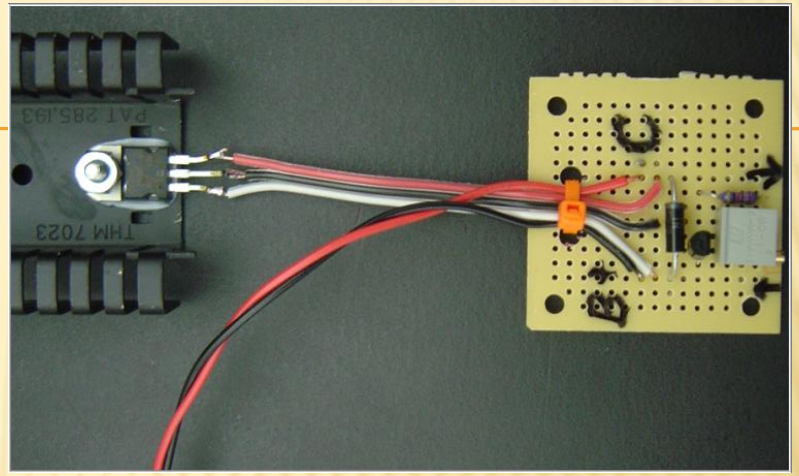
RF DECK – METERING CIRCUIT

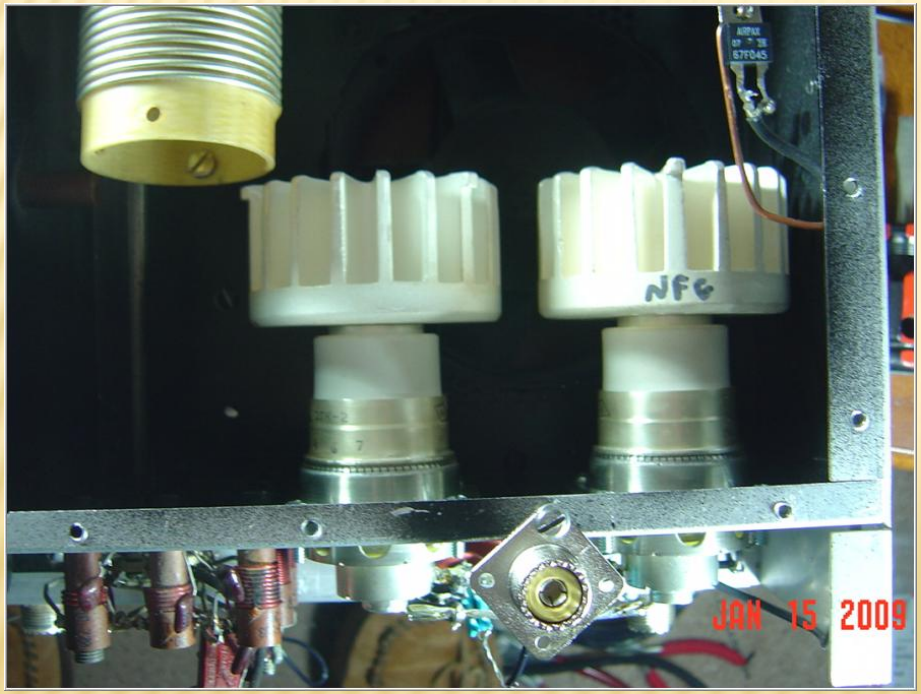


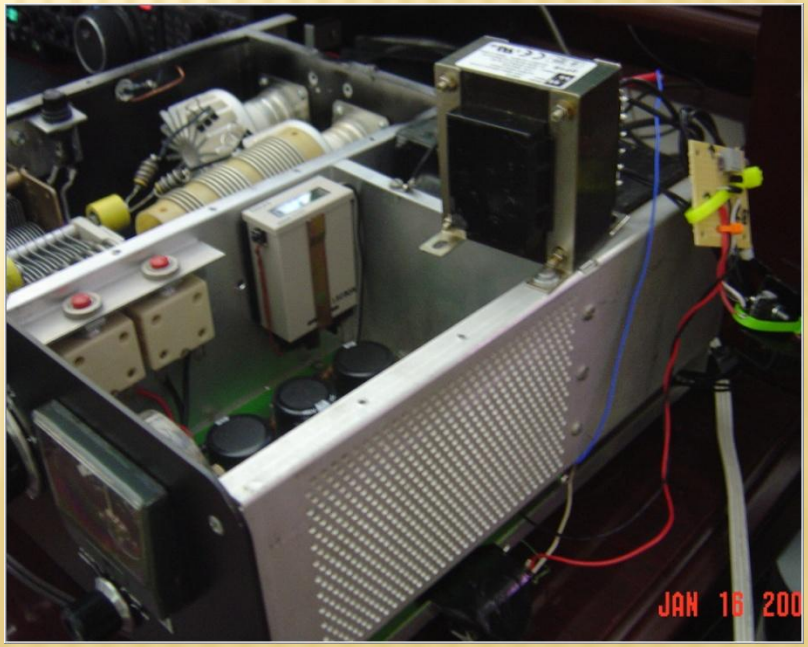
CATHODE CIRCUIT ASSEMBLY



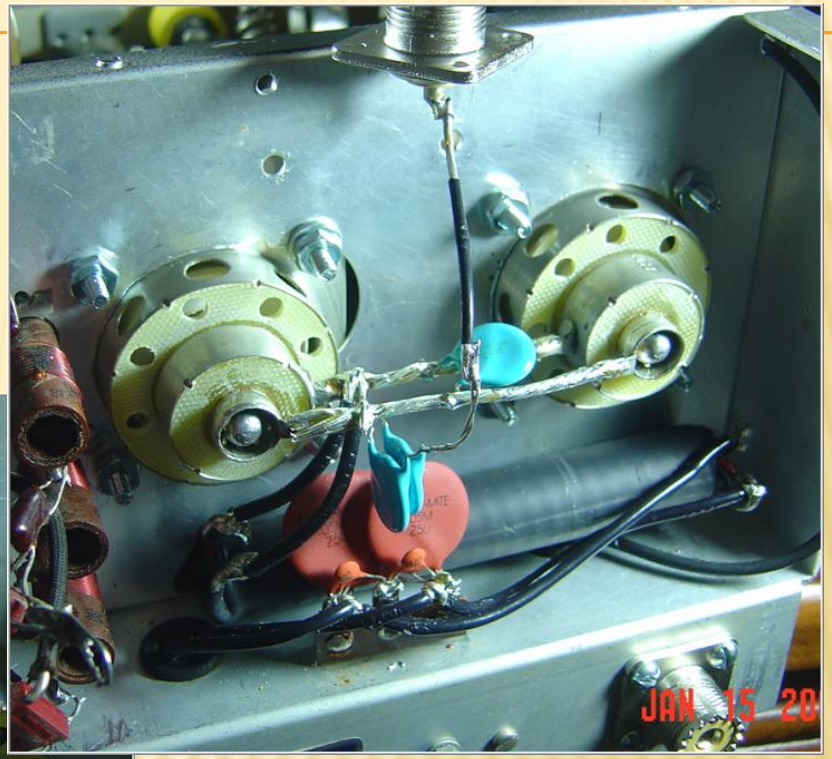
RF DECK
BIAS BOARD

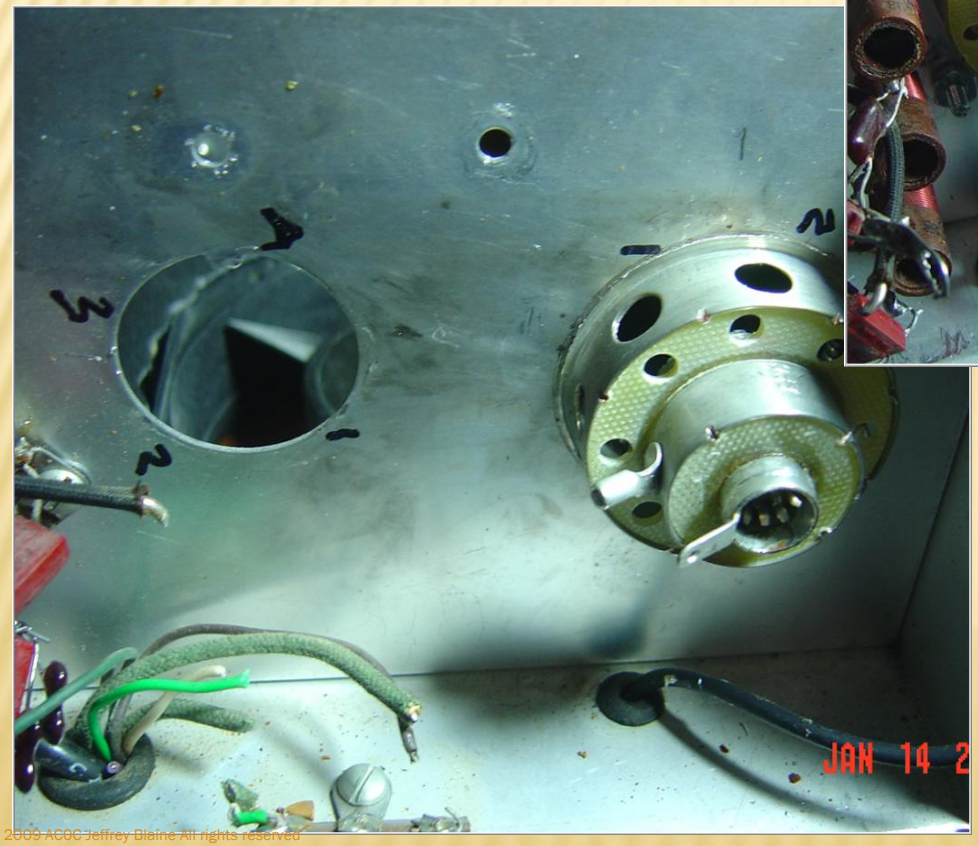


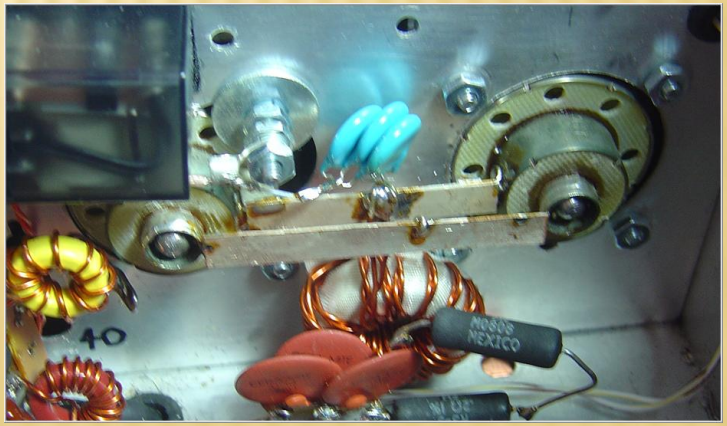




GRID CIRCUITRY







GI7B - INITIAL TEST RESULTS

TEST F
80m → DL

Ip Idle = 90mA
LP100 – Avg PWR

		Ip	Ig	HV	X
~~46~~ ~~50~~w IN	760 OUT	650	190	2125	16.5
38 ~~40~~w IN	660 OUT	500	110	2150	17.4
29 ~~30~~w IN	530 OUT	420	80	2175	18.3
20w IN	390 OUT	330	50	2200	19.5
50w IN	800 OUT	580	150	2100	16
55w IN	870 OUT	620	180	2075	15.8
60w IN	890 OUT	610	190	2075	14.8
65w IN	945 OUT	650	7200	2075	14.5

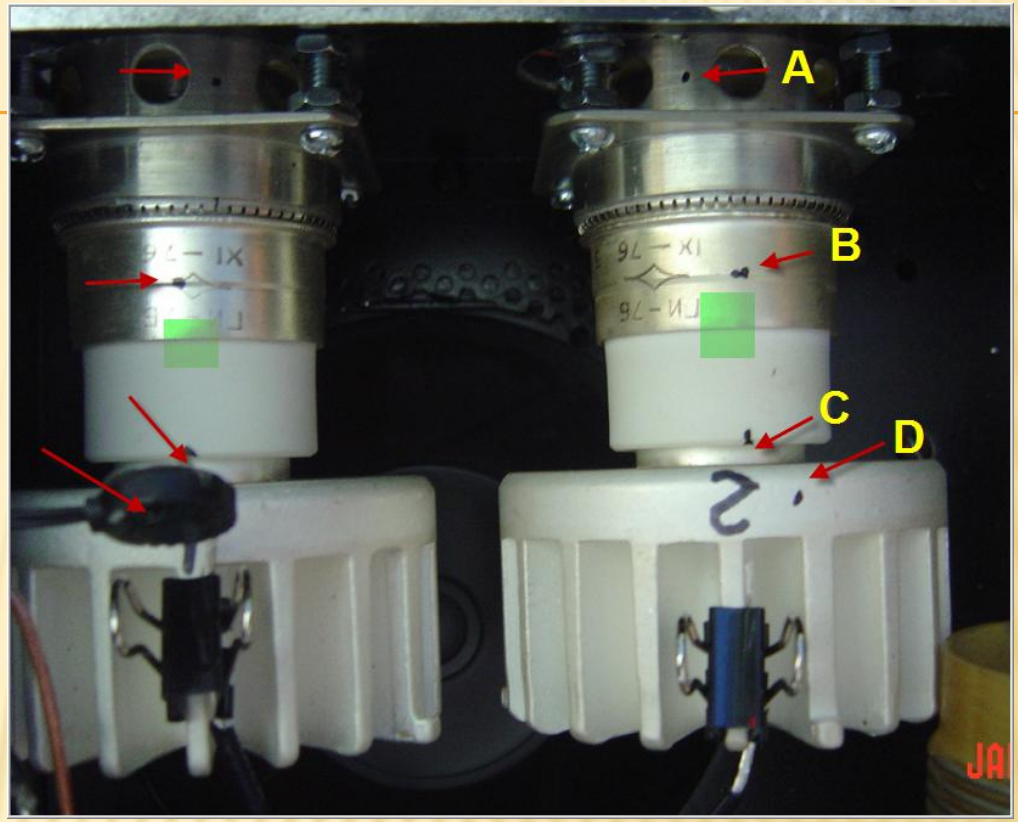
Pad est

65w/ P_{in} = 2075 x 0.65 = 1350w P_{in}
− 945w P_o
405w Plate dis
= 70%

50w/ P_{in} = 2100 x 0.58 = 1220 P_{in}
− 800w P_o
420 w Plate dis
= 66%

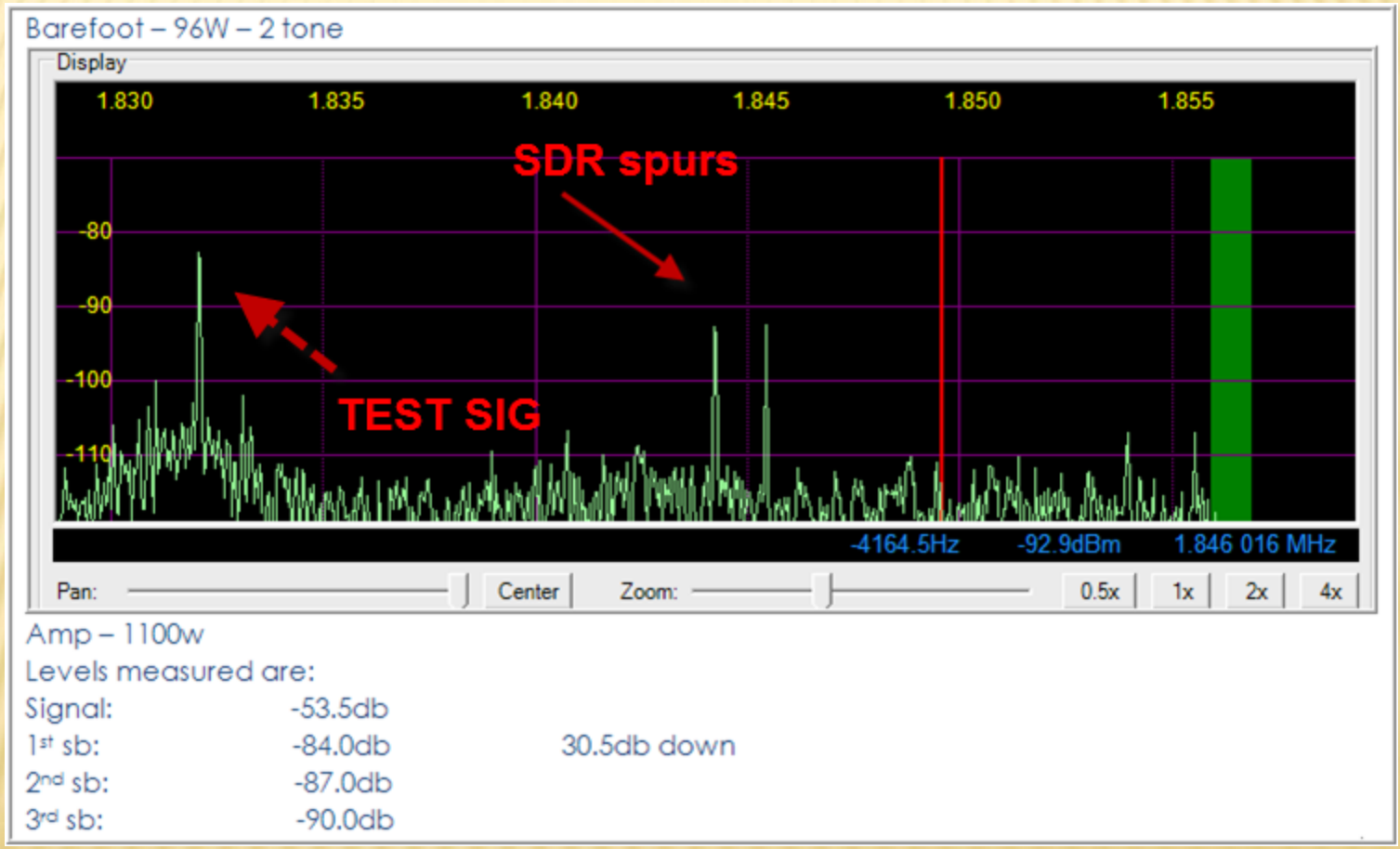
40w/ 2125 x.540 = 1150 P_{in}
− 680w P_o
470w Plate Dis
= 59%

RTTY DUTY - TEMP PROFILE



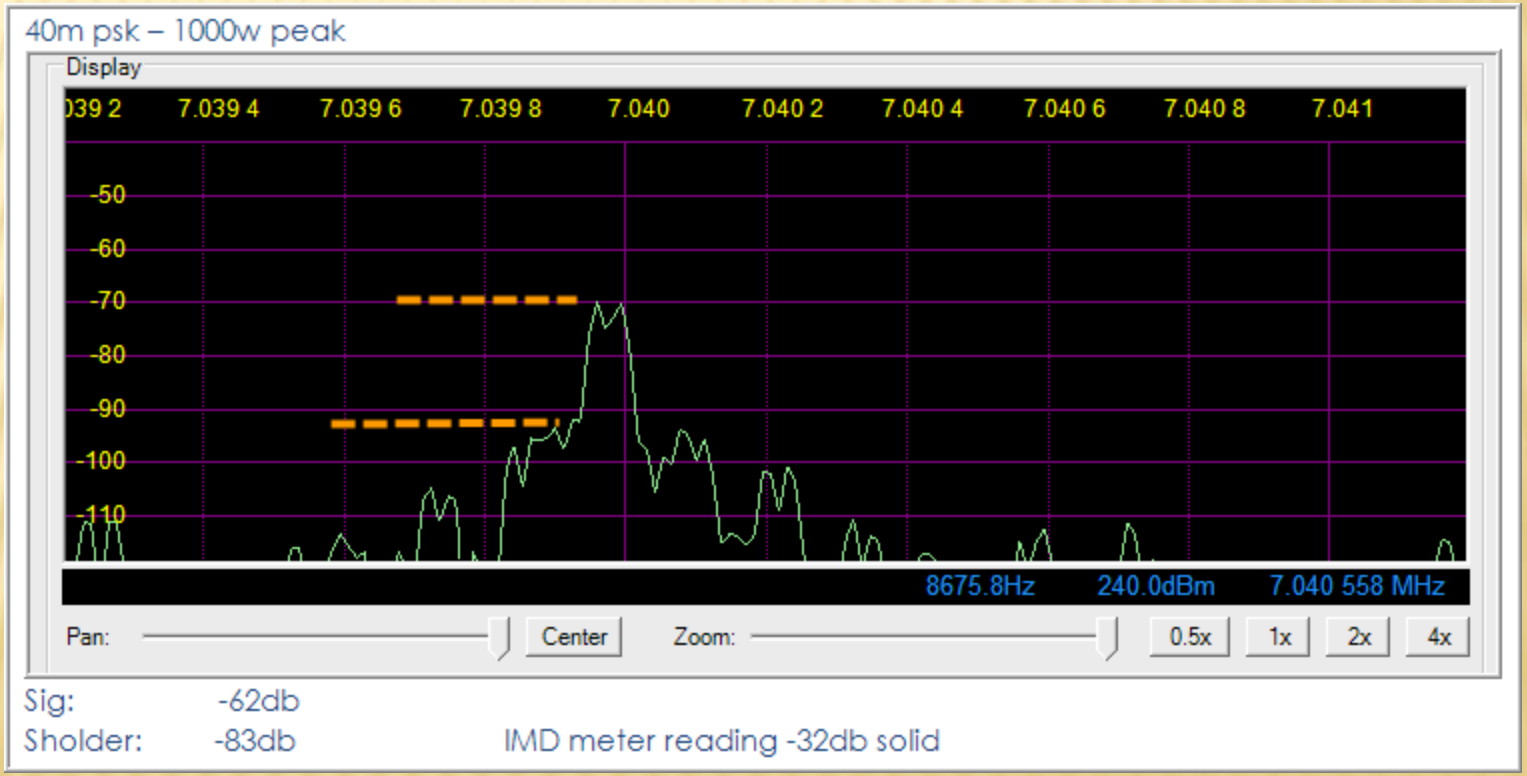
Elapsed	Socket (A)	Body (B)	Anode plate (C)	Heatsink (D)	TX
0 min – idle	36	98	41	50	40
1 min	37	110	50	60	
2 min		130	n/m	70	46
3 min		150	60	75	
4 min		170	70	80	
5 min		170	70	85	
6 min	50	185 *	70	95 *	53-56

BAREFOOT – SIG QUALITY BASELINE



SDR AS SPECTRUM ANALYZER

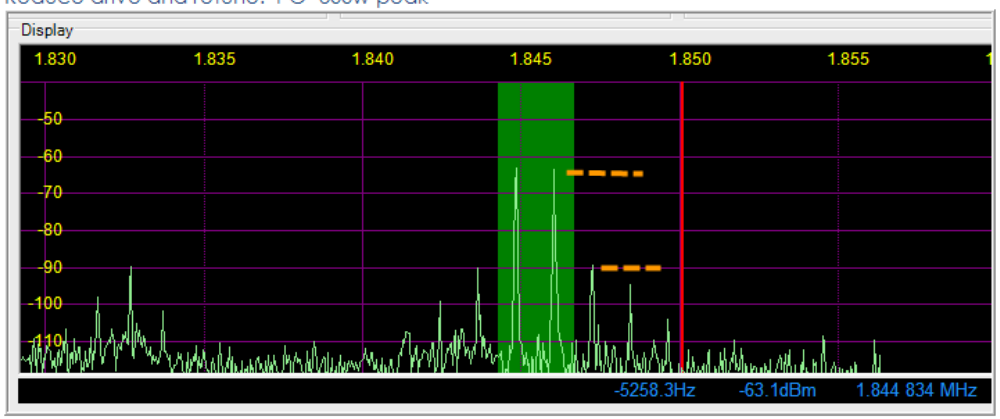
- Full power test using PSK as 2-tone source
- 3rd-order products -31db down @ 1KW output



SDR AS SPECTRUM ANALYZER

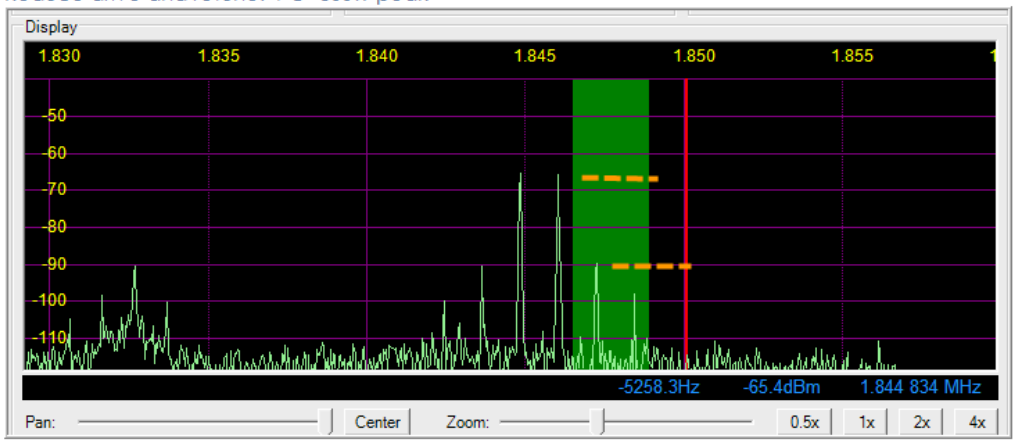
- Easy way to check emission products
- Interesting results – lower power drive increases distortion products

Reduce drive and retune: PO=500w peak



Sig: -56db
1st sb: -83db 27db difference

Reduce drive and retune: PO=300w peak



Sig: -59db
1st sb: -84db 25 db difference

Conclusion: Lower power results in poorer IMD performance

EXPERT CONFIRMATION

From: Adam Farson [mailto:farson@shaw.ca]
Sent: Friday, January 23, 2009 4:34 PM
To: 'Charlie Mazoch'
Cc: Jeff Blaine
Subject: RE: [Fwd: RE: sb200 sleeper project - 22 Jan 09 - 2-tone testing results]

Hi Charlie,

Excellent work. I see that Jeff's best IMD3 figure is approx. -32 dBc at 1 kW PEP (referred to one of 2 equal tones, per ITU-R method). This is 7 dB better than the ITU-R spec, and is equivalent to 38 dB below 2-tone PEP.

That is superb by any measure.

Cheers for now, 73,
Adam VA7OJ/AB4OJ

PROOF OF CONCEPT RESULTS

- GI7B works well
- Stock SB200 TX provides great capability
- Signal quality very good with stock tank
- Results FB - so on with the show!

Next Step

TANK MODS

TANK AND INPUT MATCHING

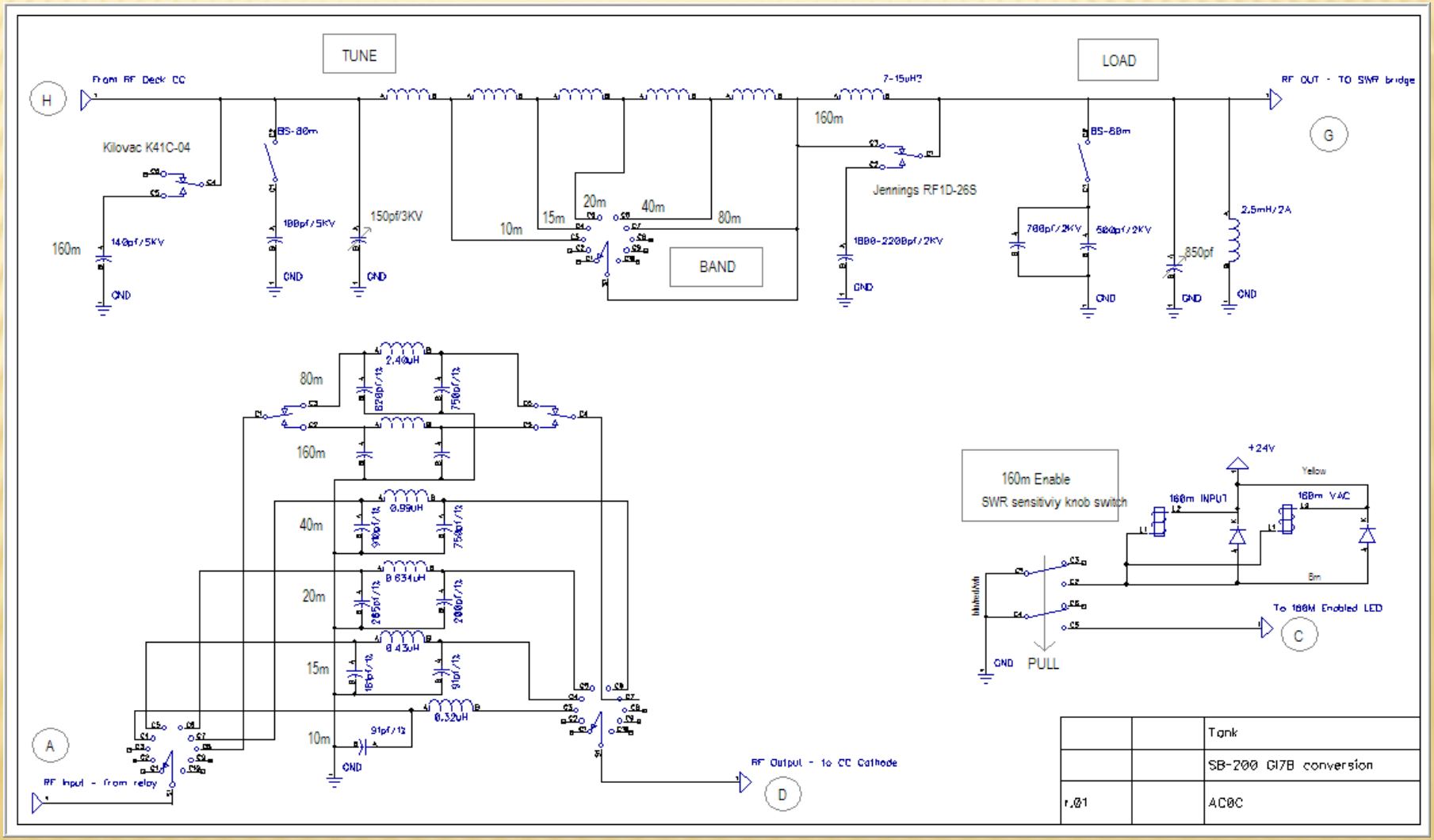
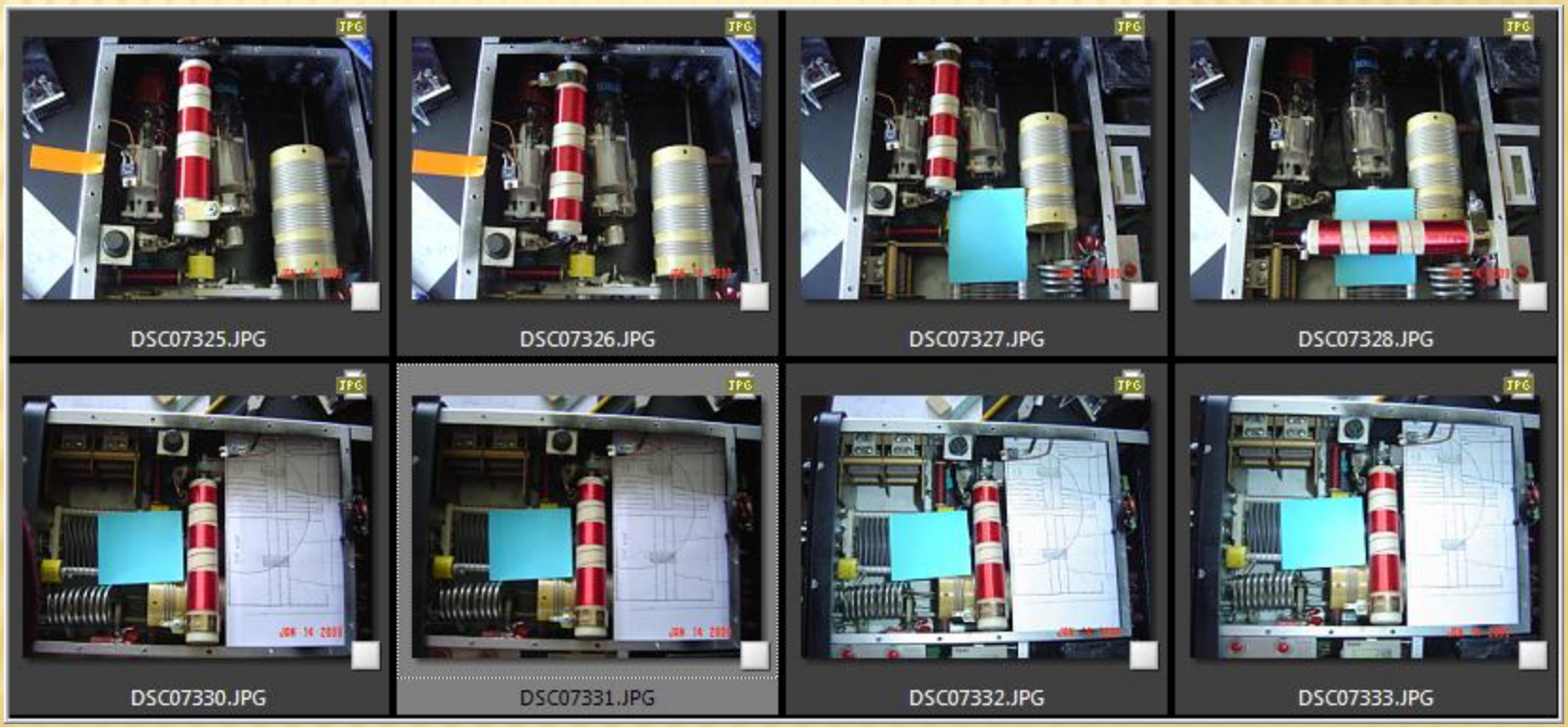
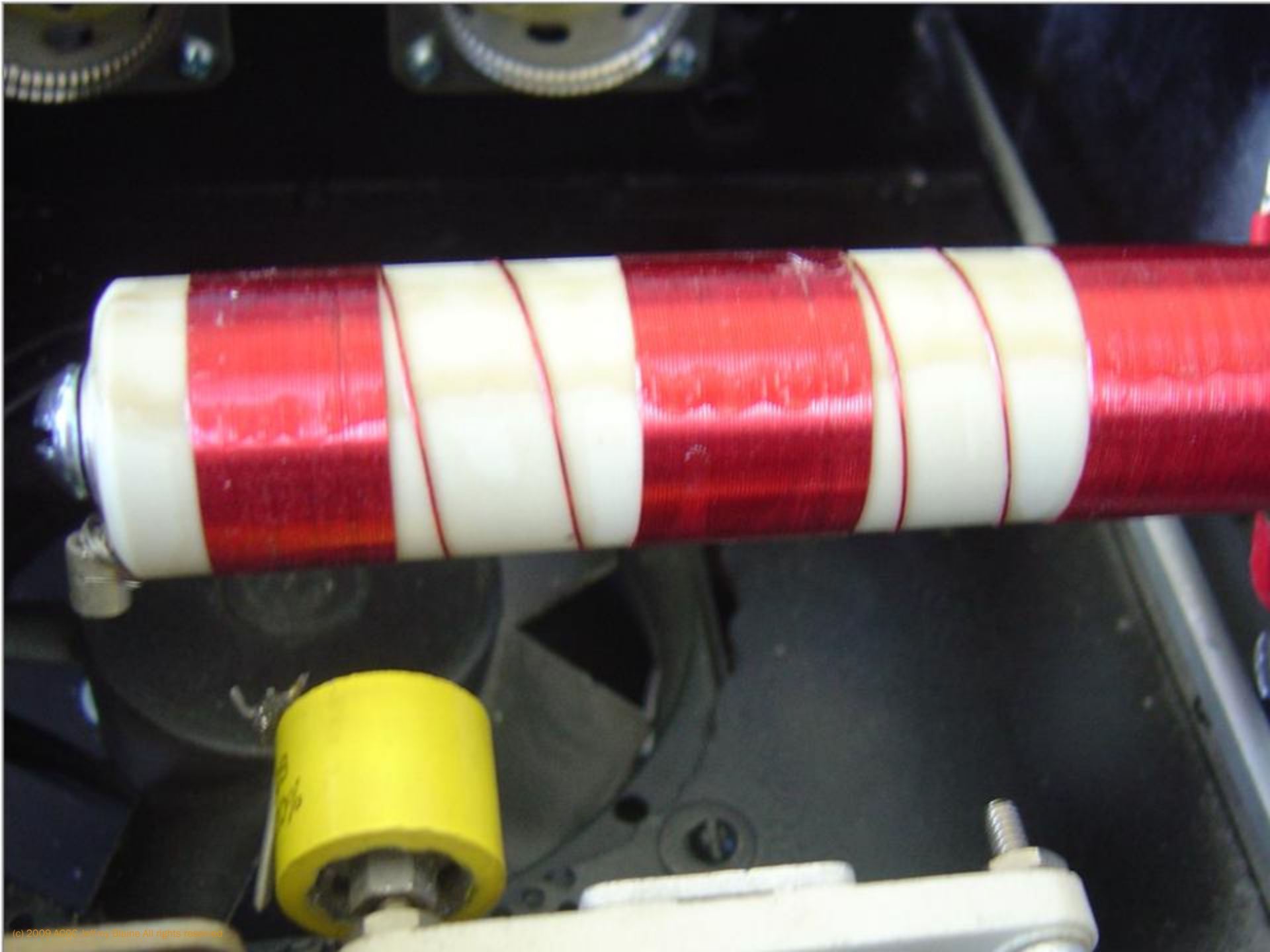
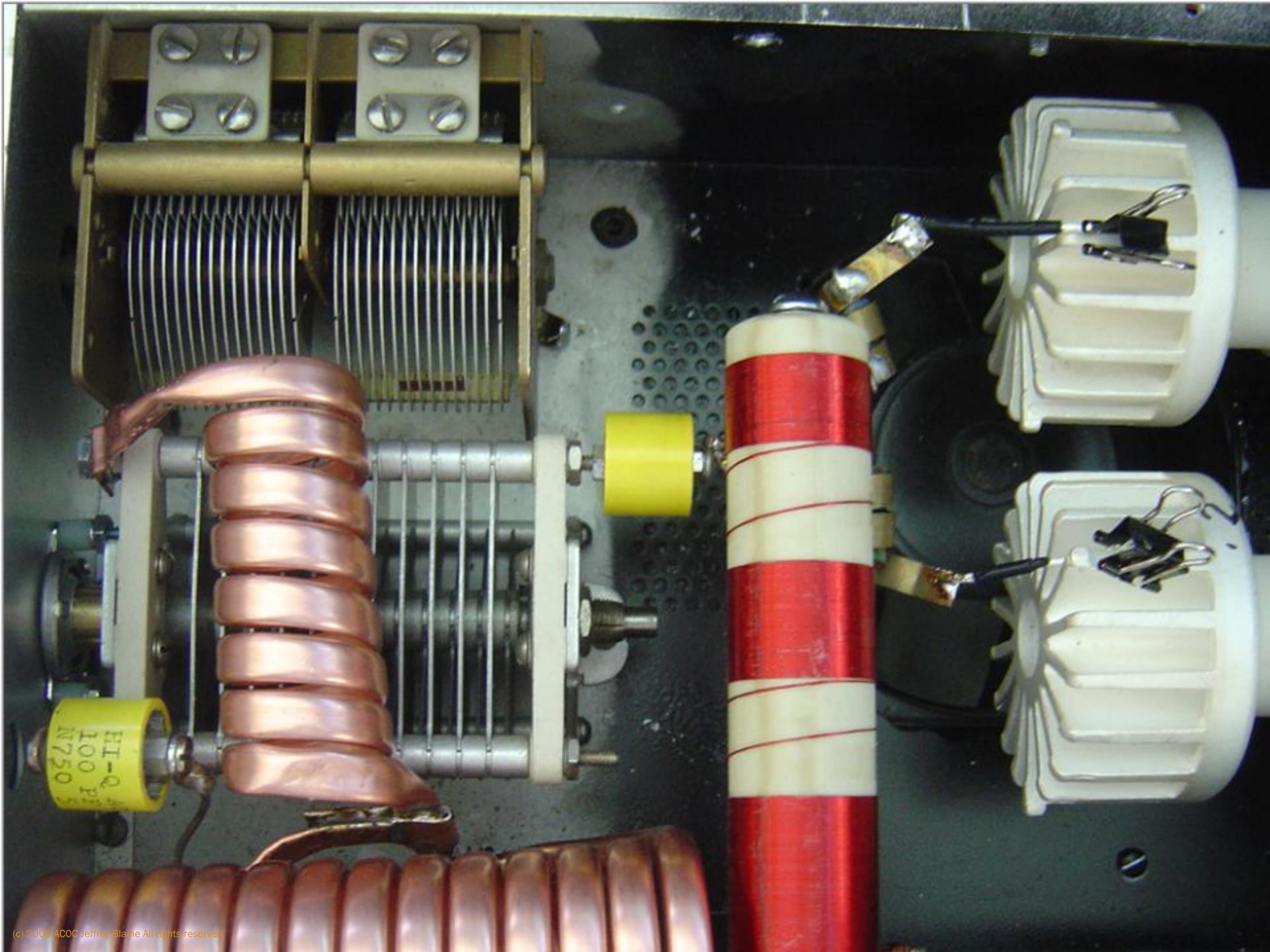
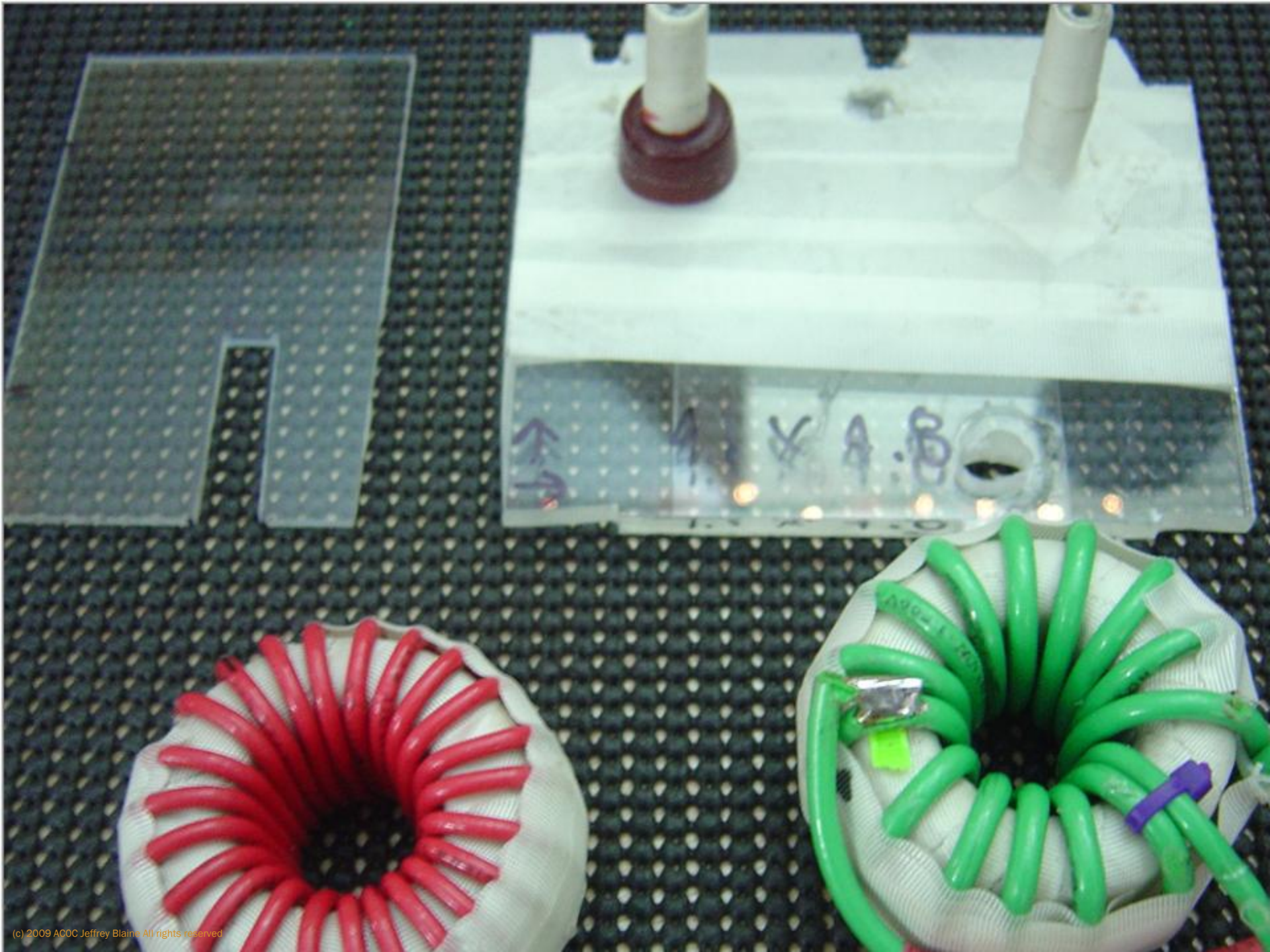


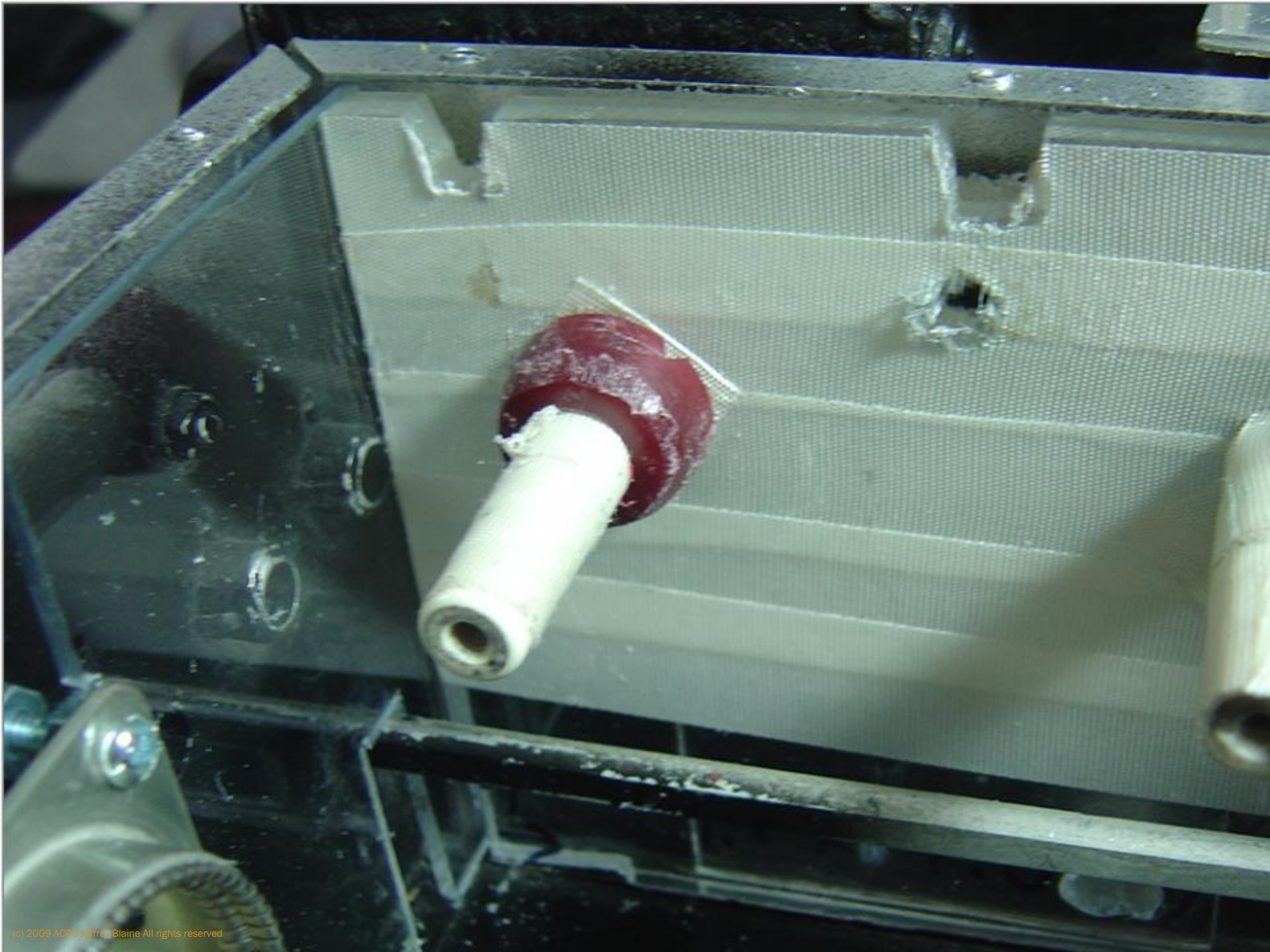
PLATE CHOKE PLACEMENT

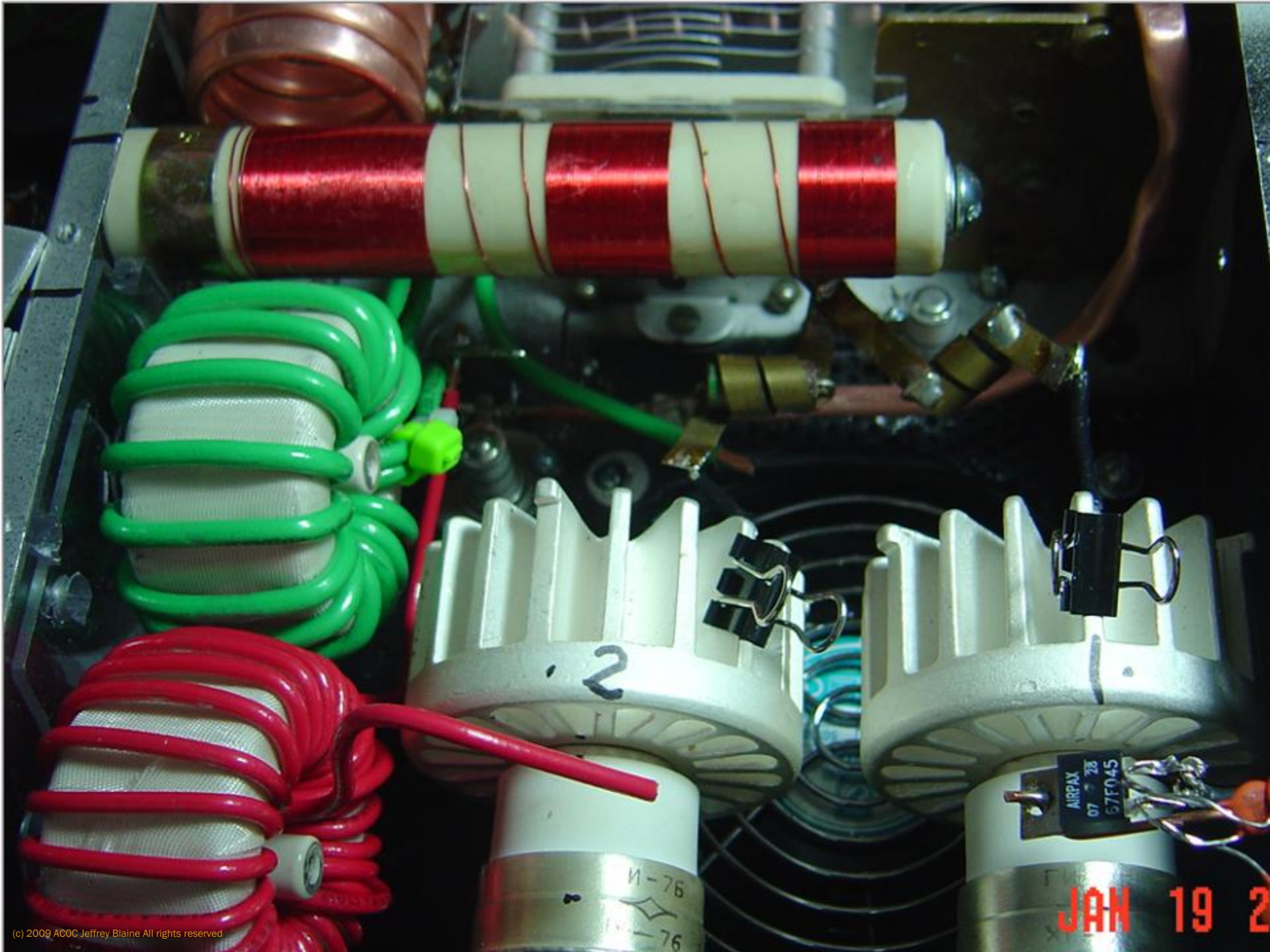


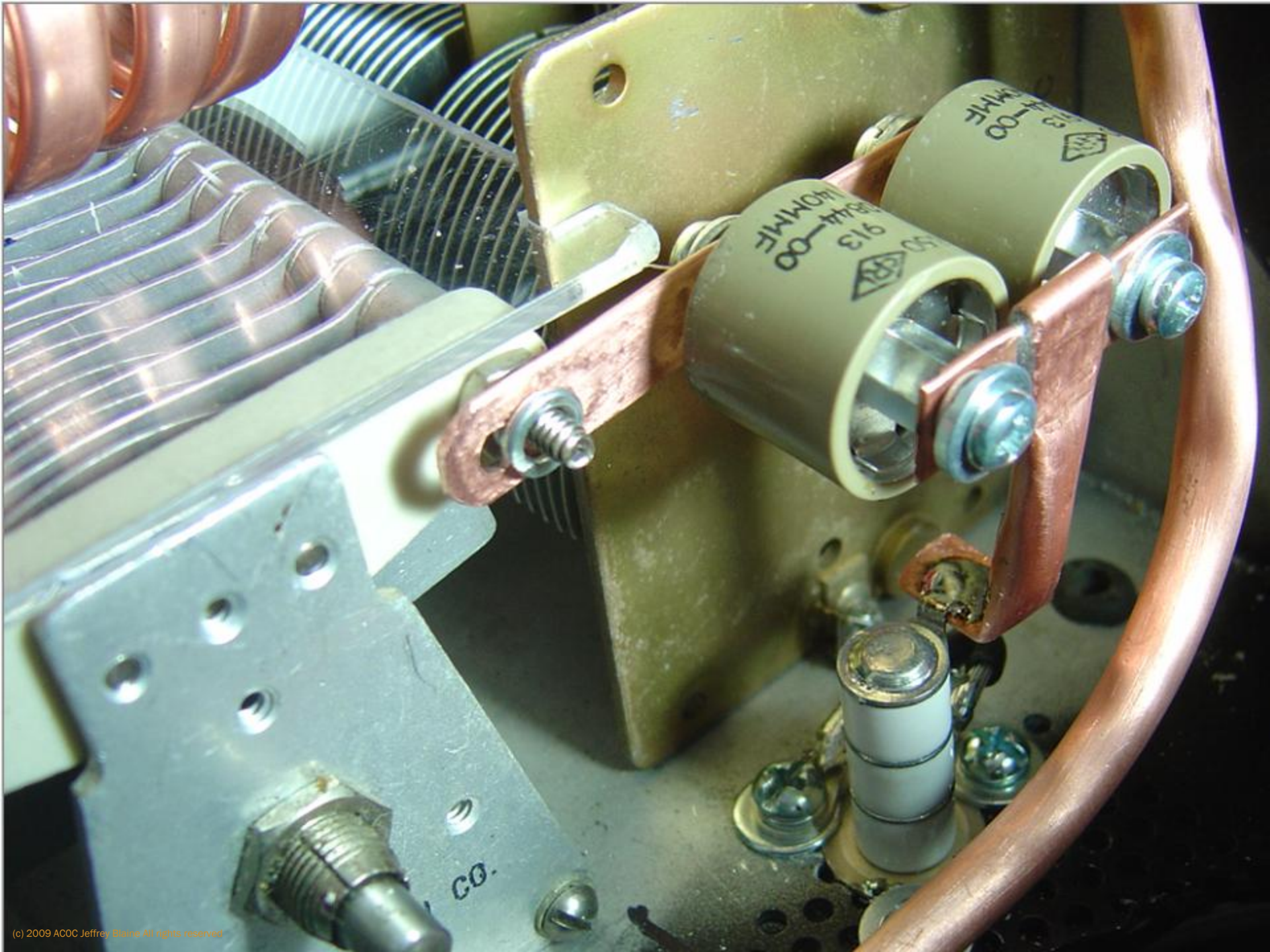


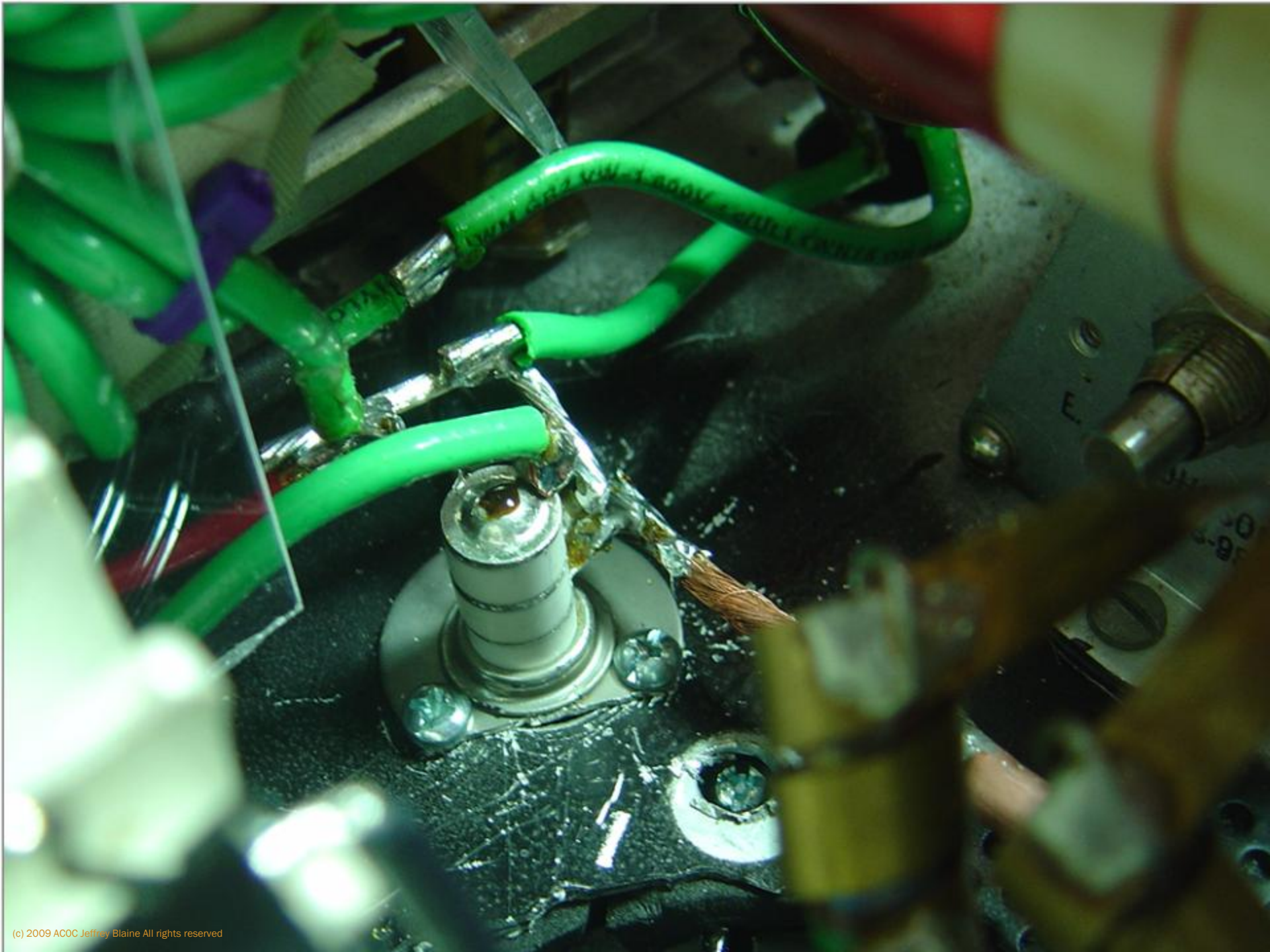




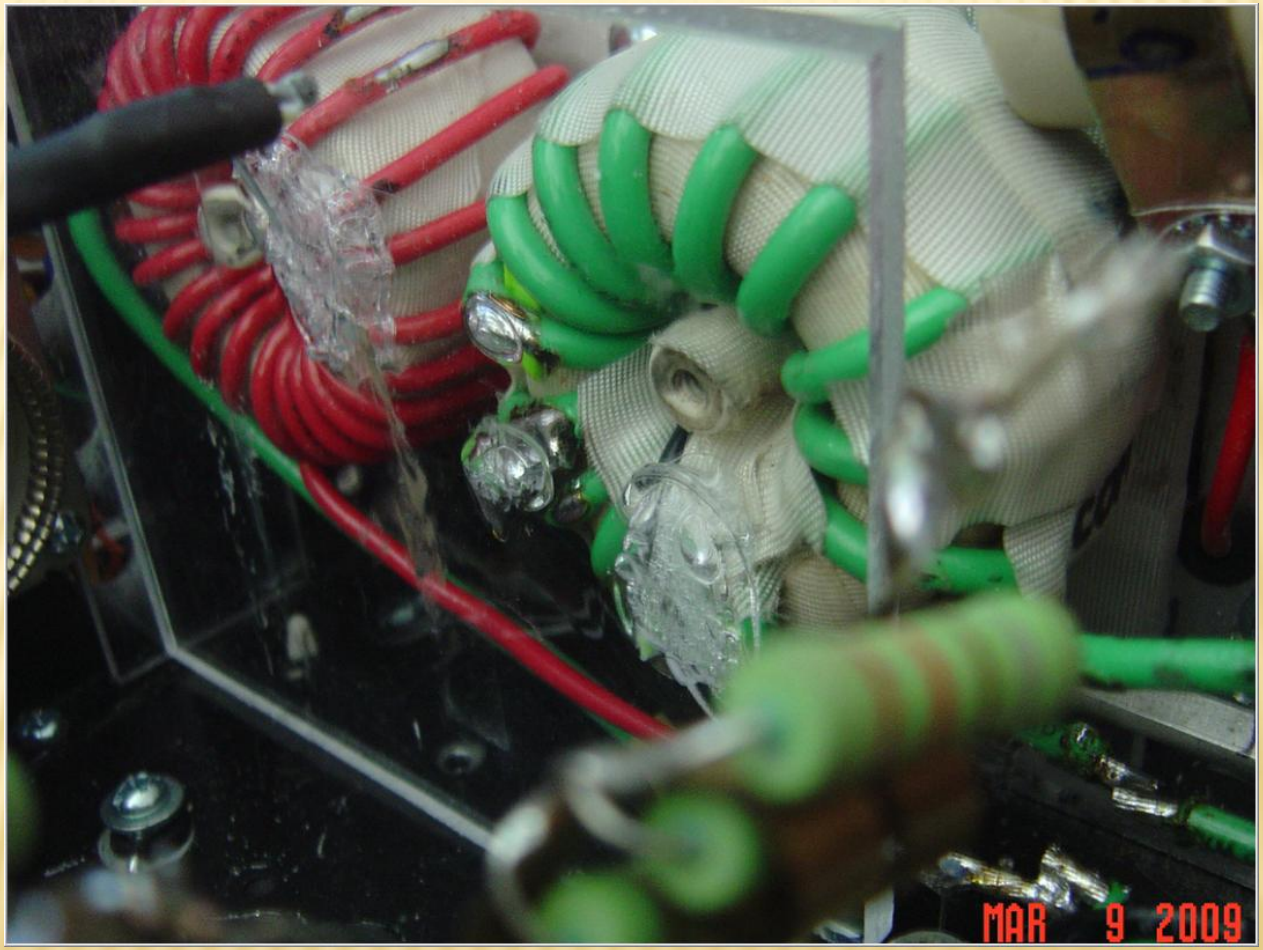






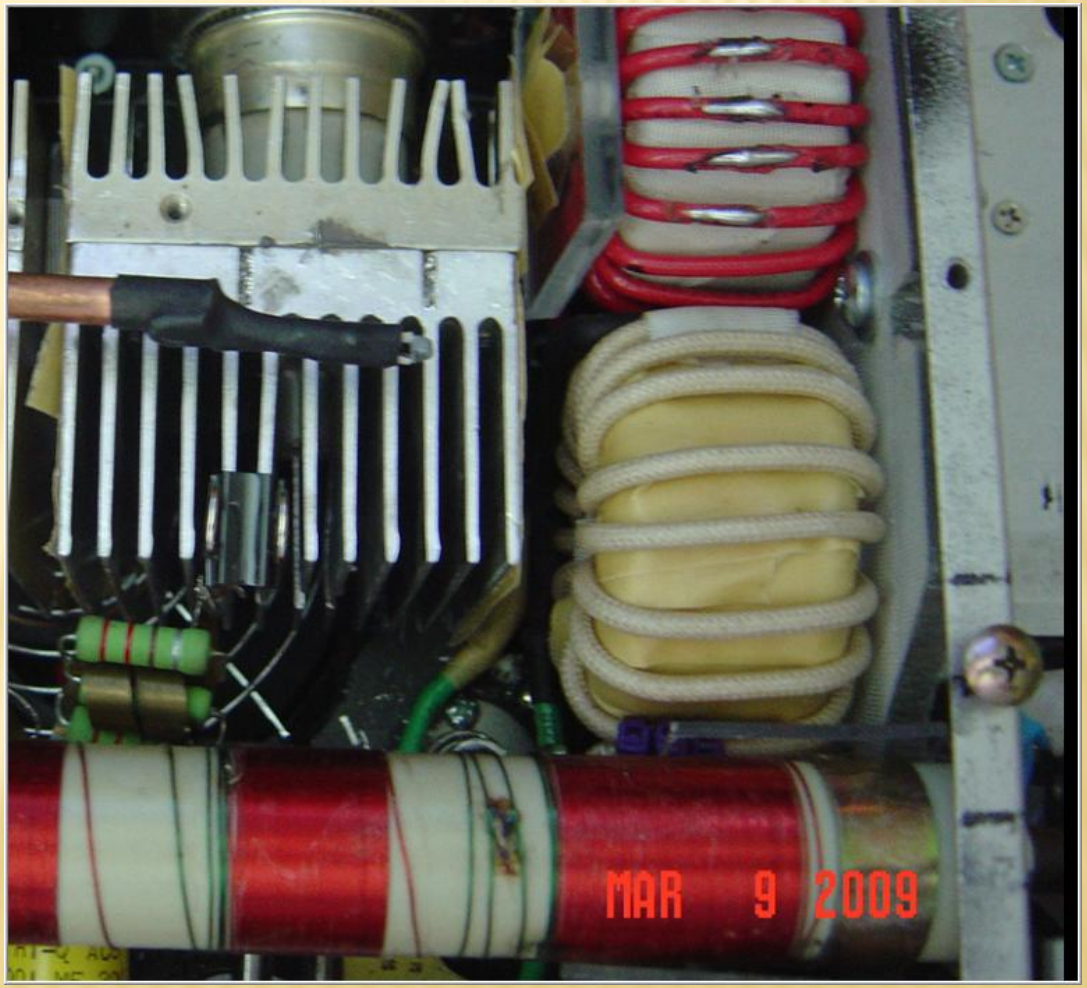


TOROID HEATING



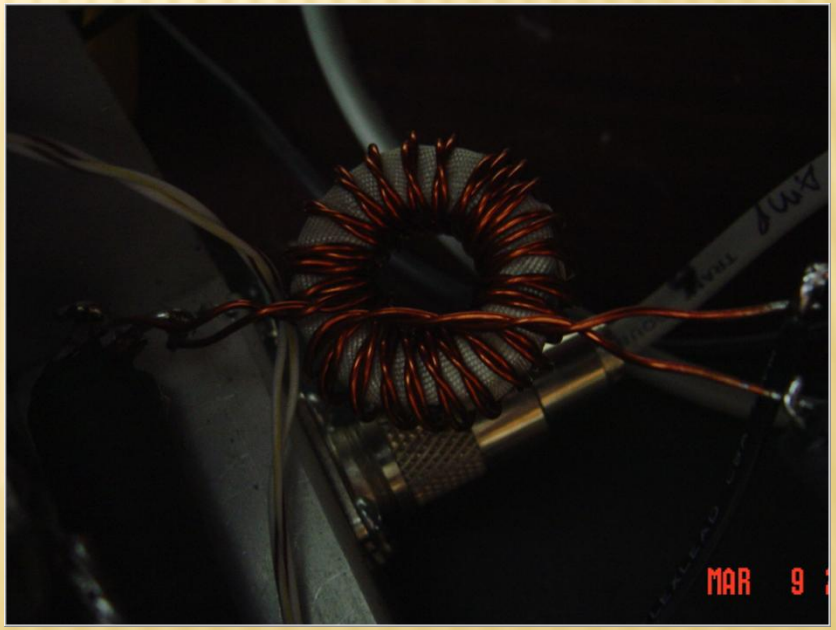
NEW 40/80M TOROID

- 200C wire
- High voltage insulating tape



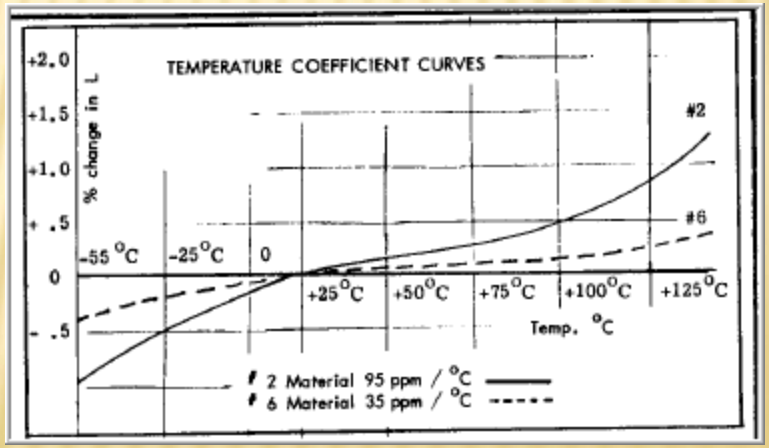
STRANGE BEHAVIOR – 80M

- 4.0 mhz – 65% efficiency
- 3.5 mhz – 56% efficiency
- What's the cause…
  - Plate choke?
  - Fil choke?
  - Tank?

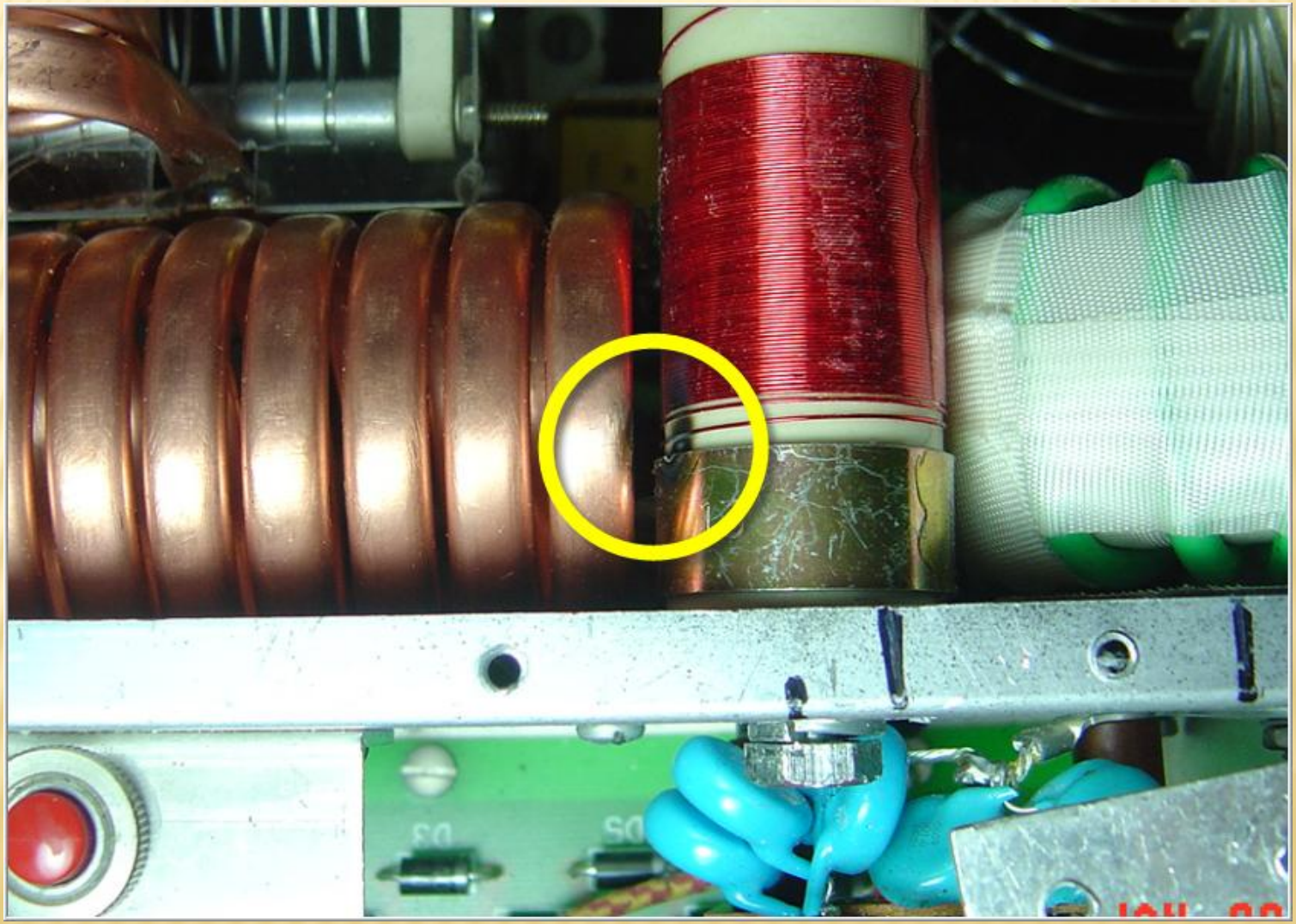


TANK Q VS. EFFICIENCY – TOROID HEATING

	Amp Eff	PD%	Pd avg, 63w drive, 2500w b+, approx 1KW out
Starting point:	55.8%	79.5%	729w
Finishing point:	65.3%	58.9%	648w



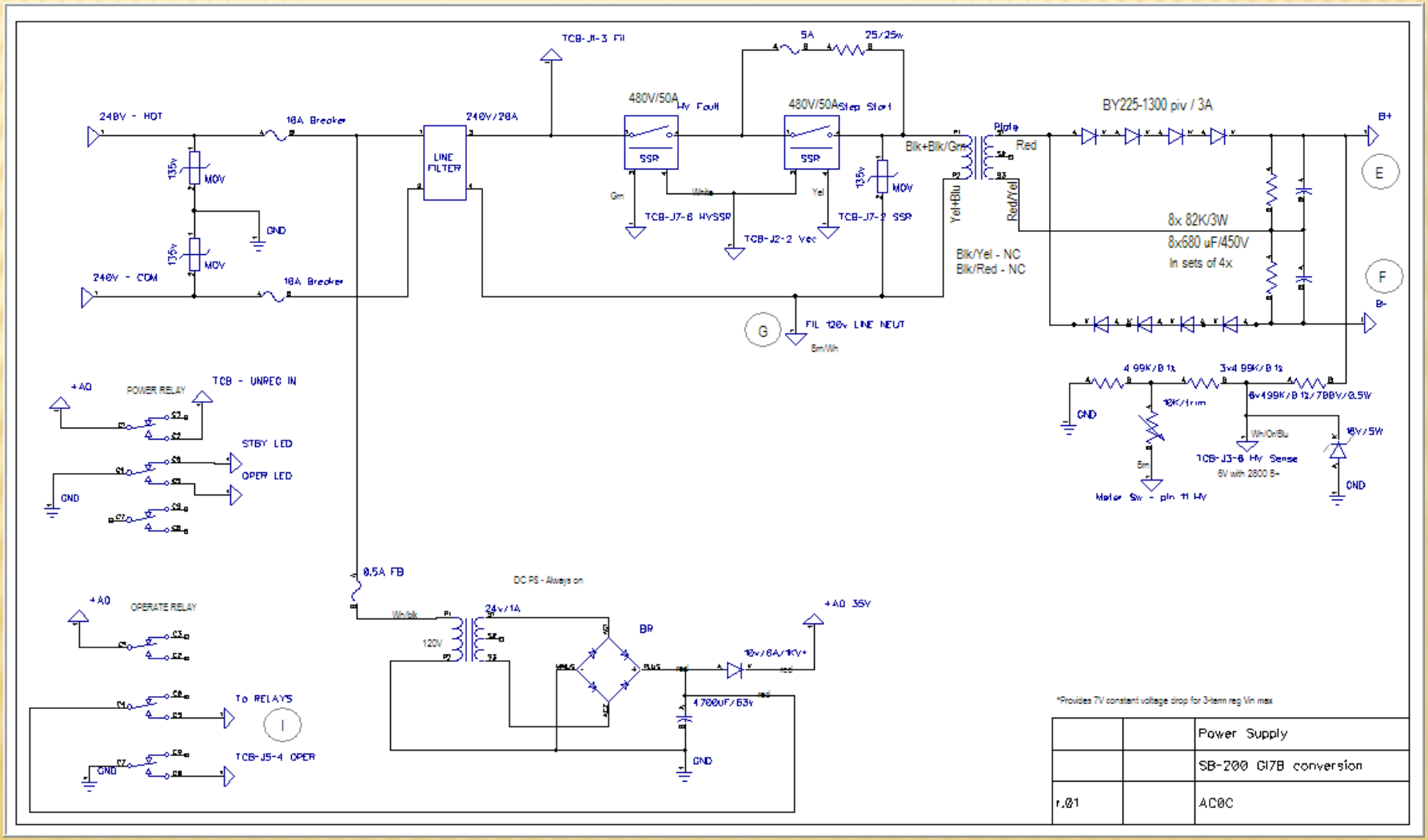
DO **NOT** PUT YOUR FINGER HERE

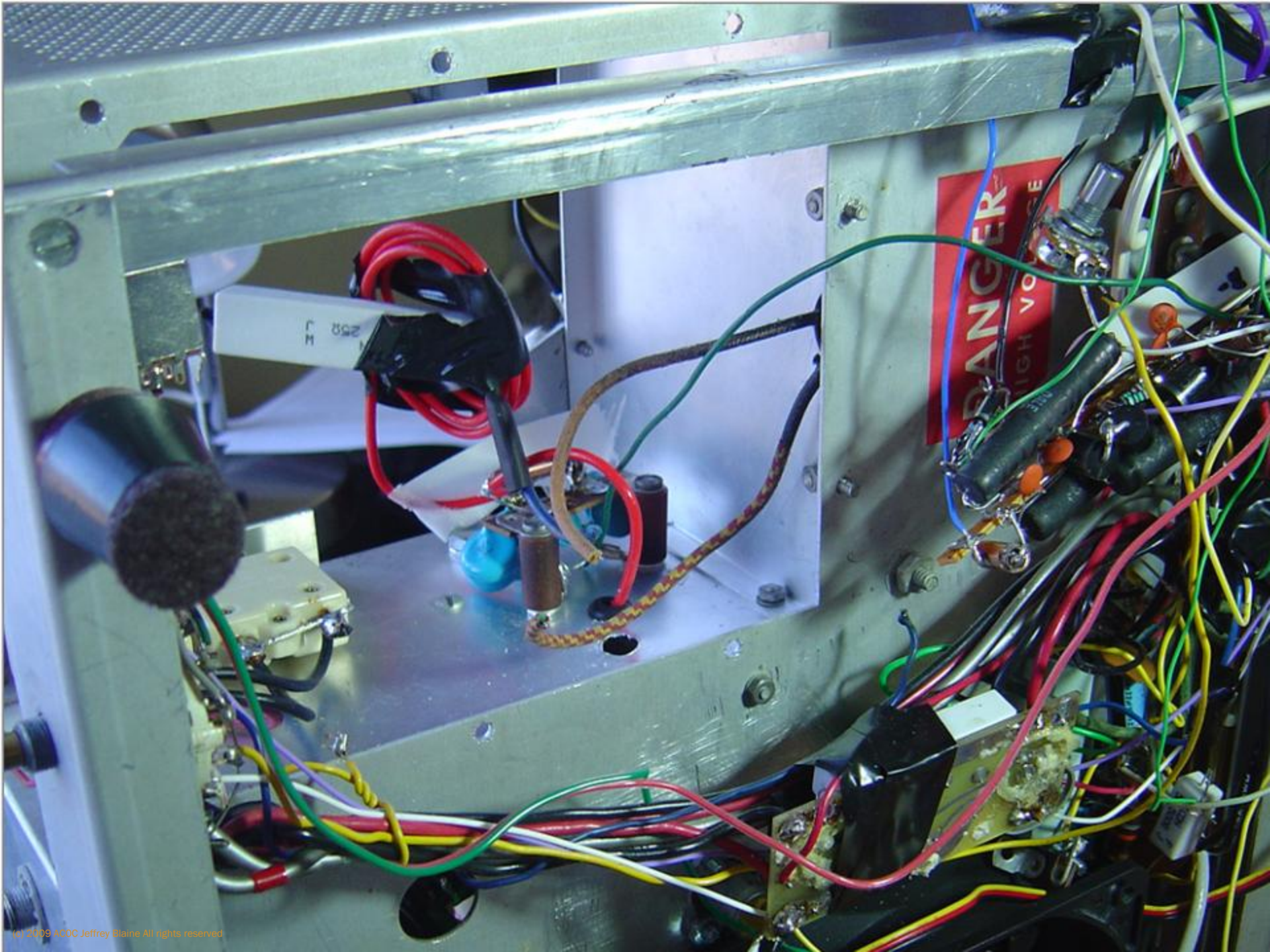


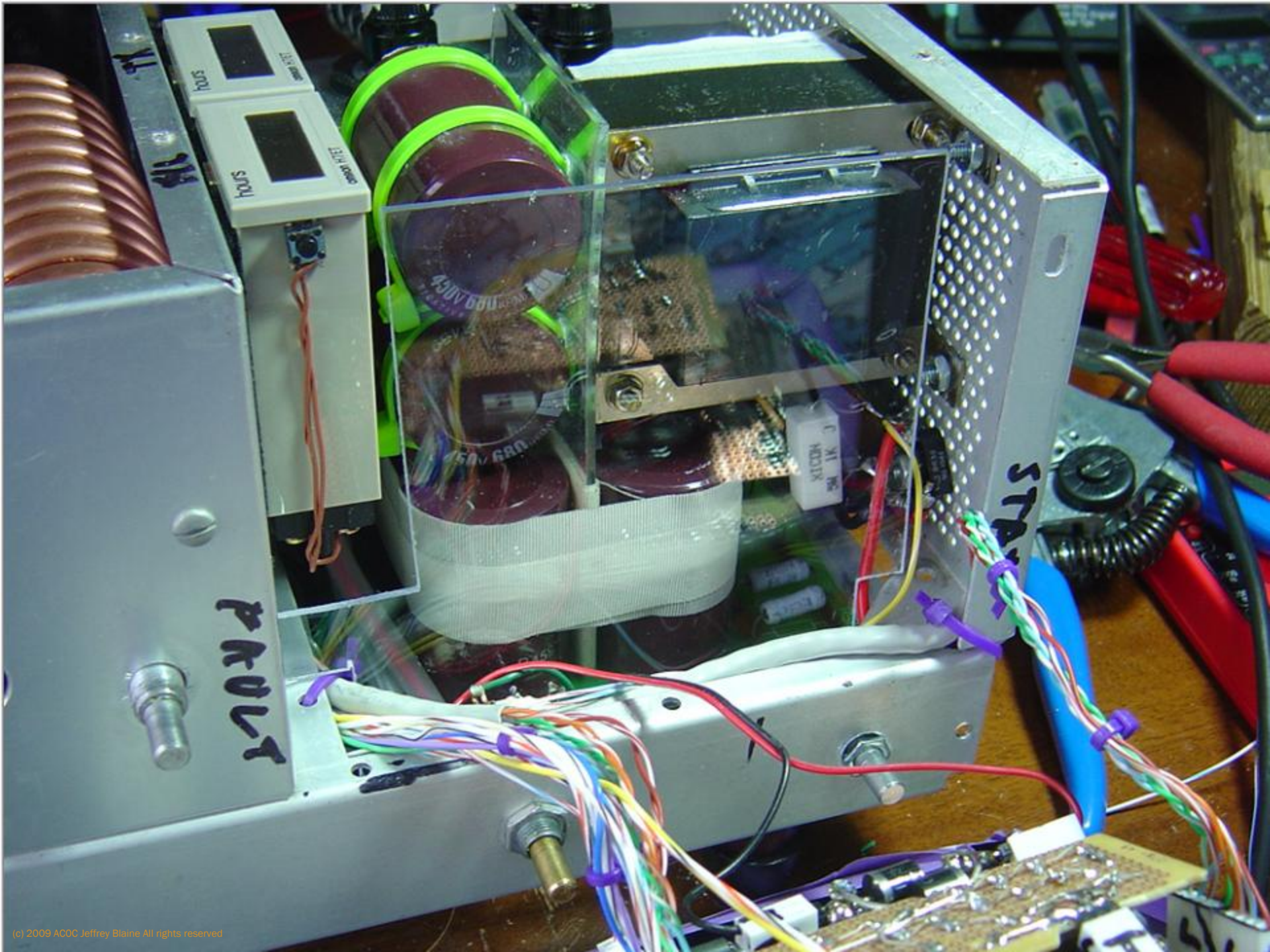
Next Step

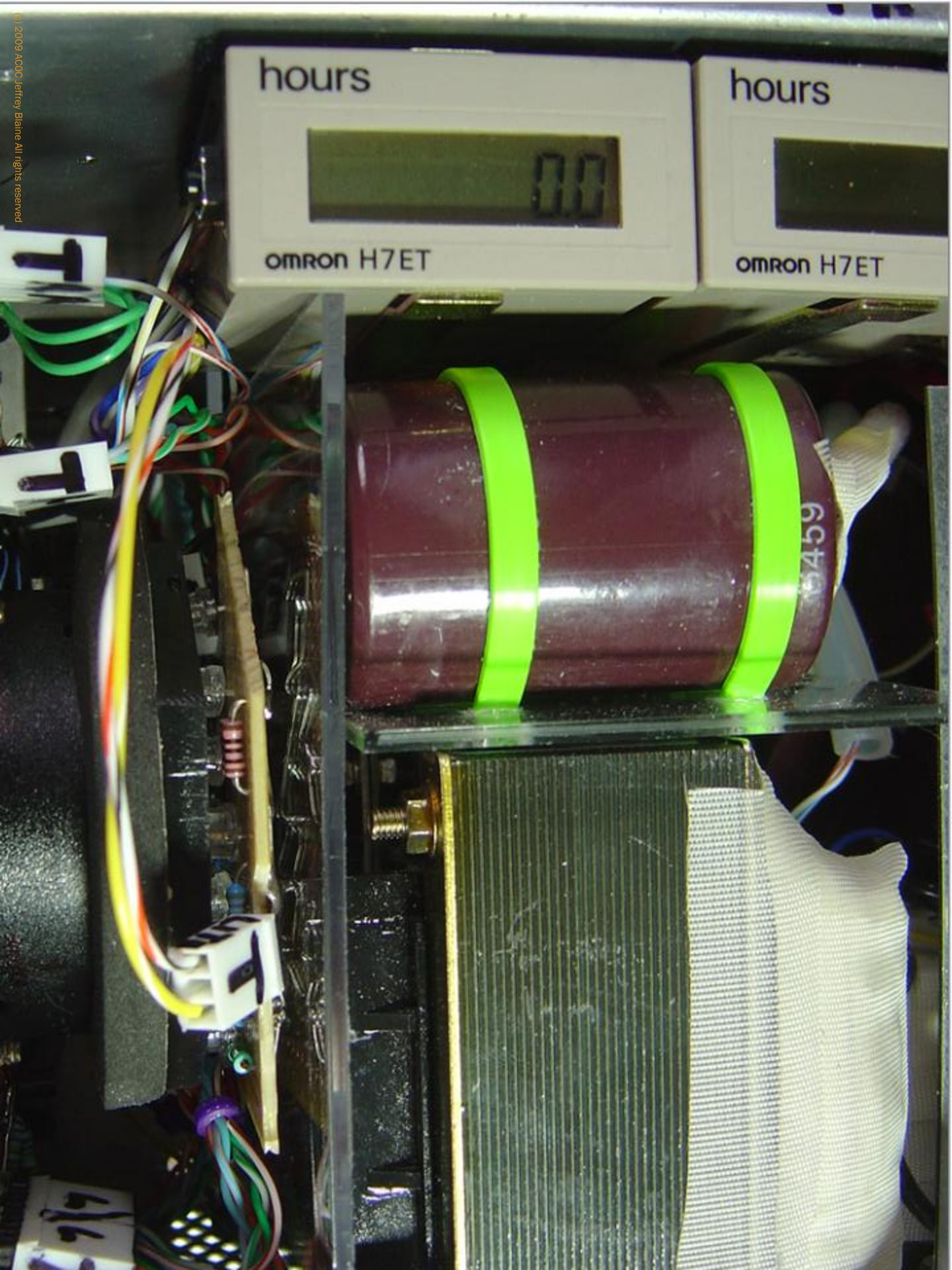
POWER SUPPLY MODS

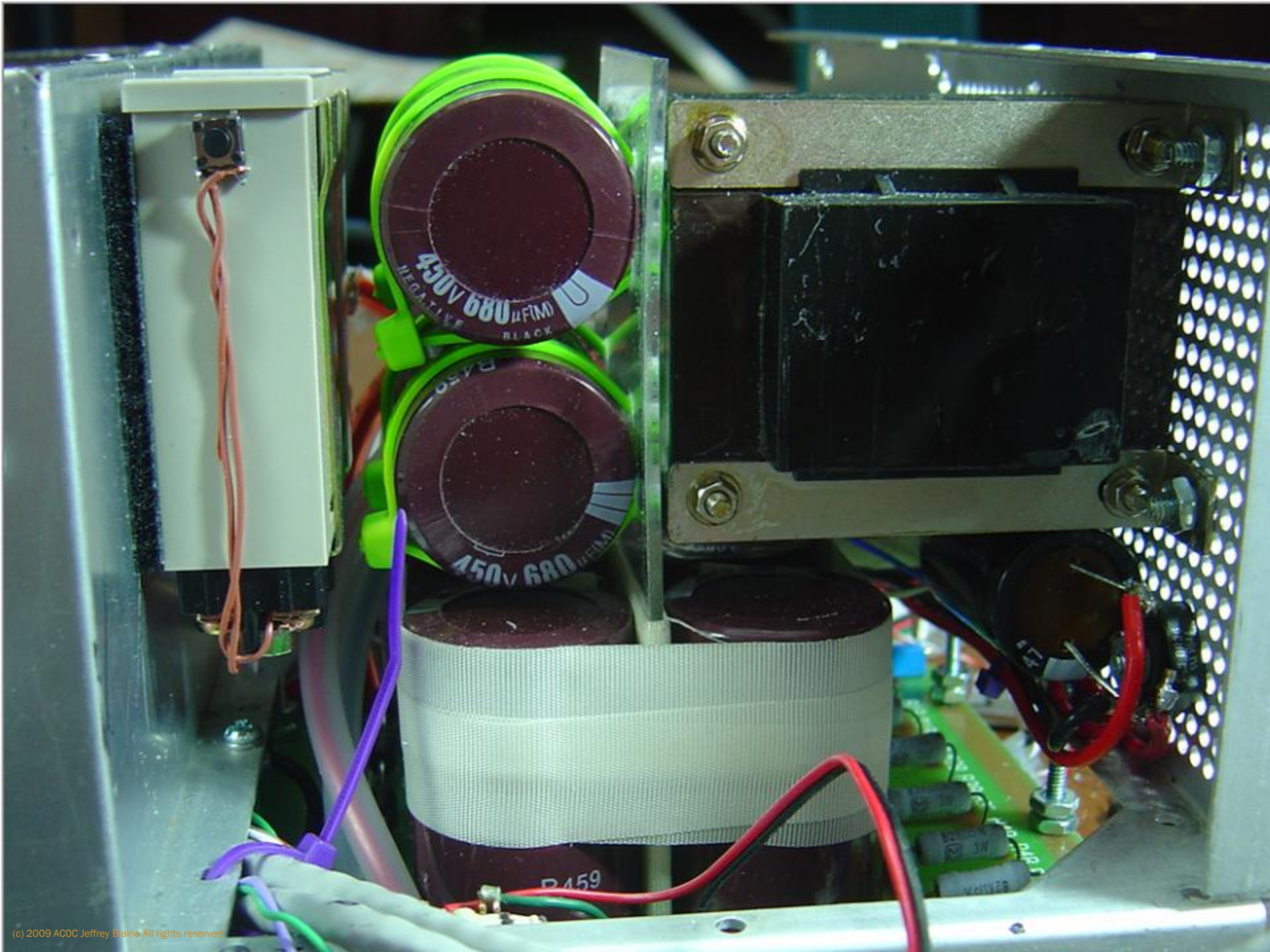
POWER SUPPLY



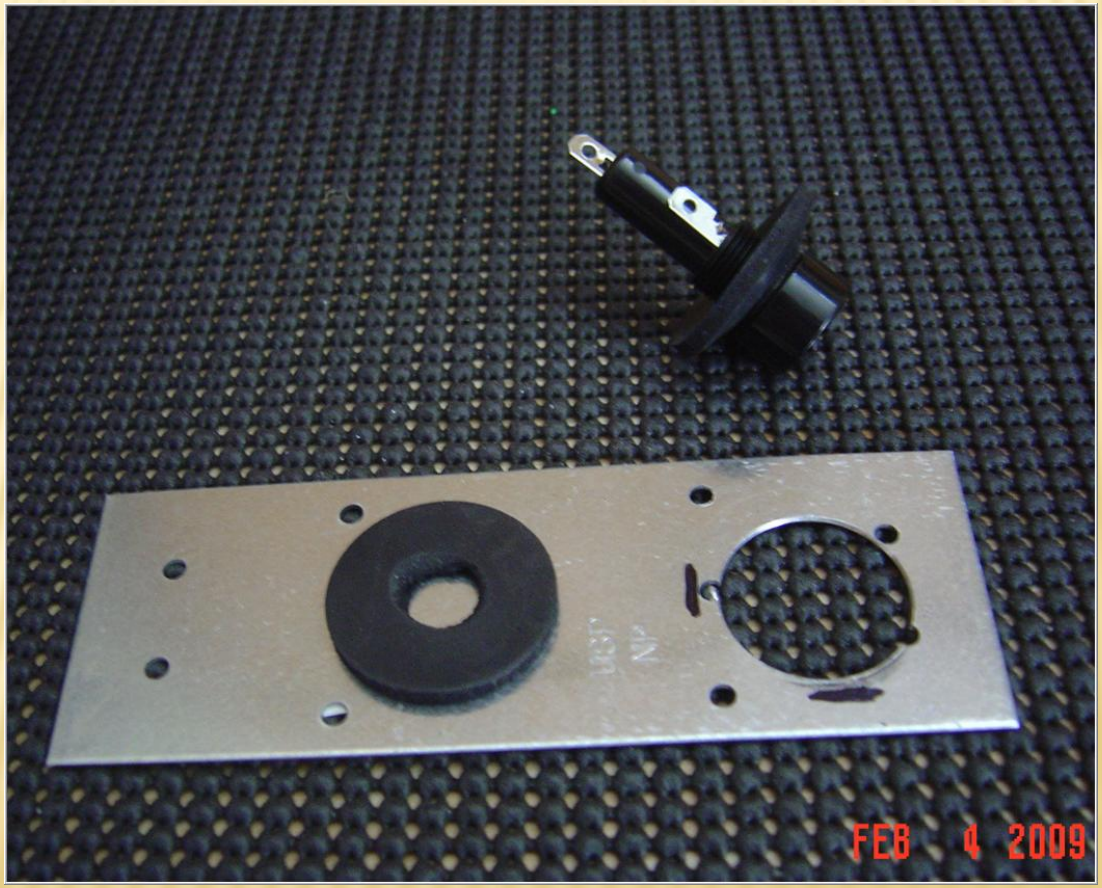


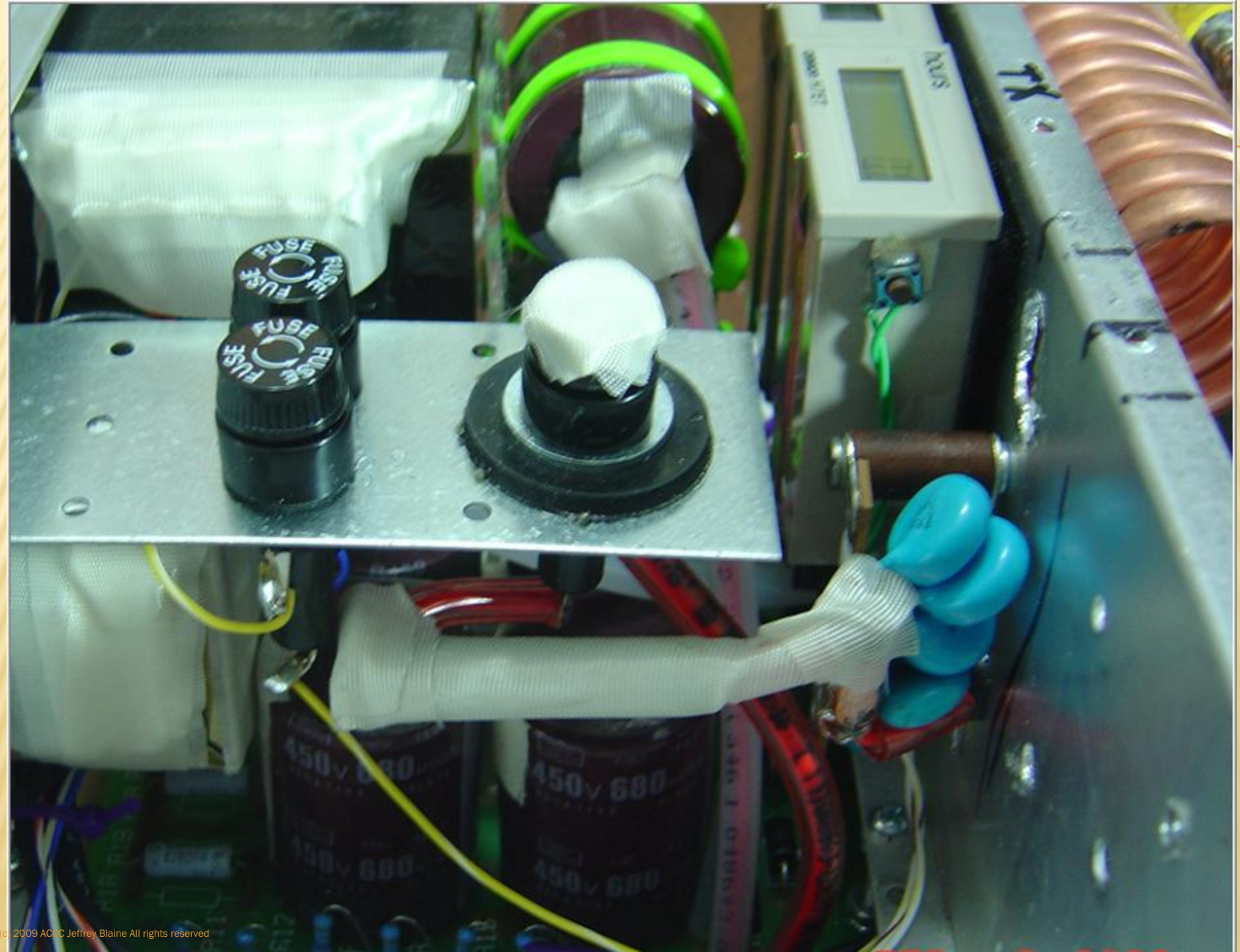


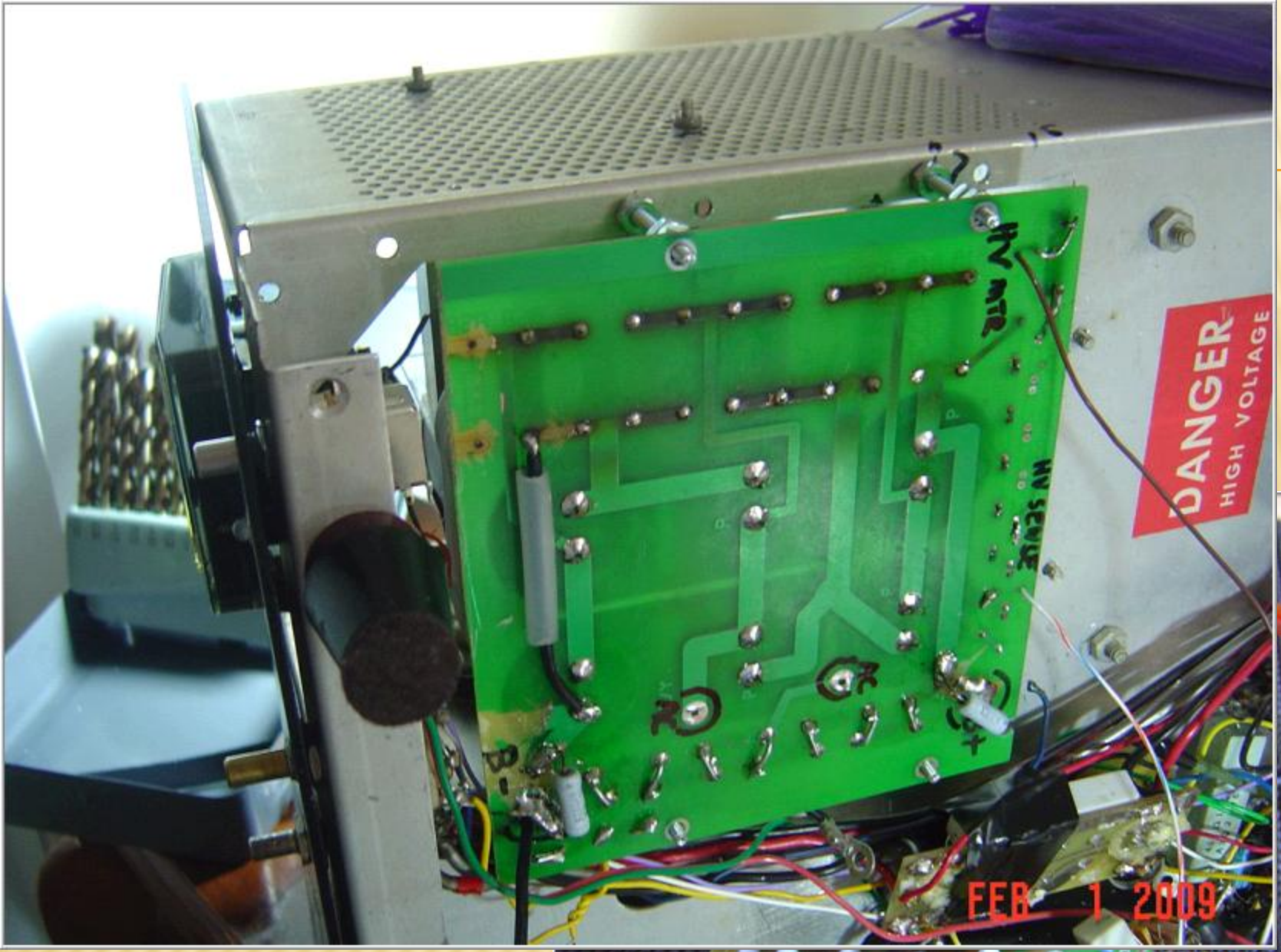




B+ GLITCH FUSE – LOW TECH INSURANCE







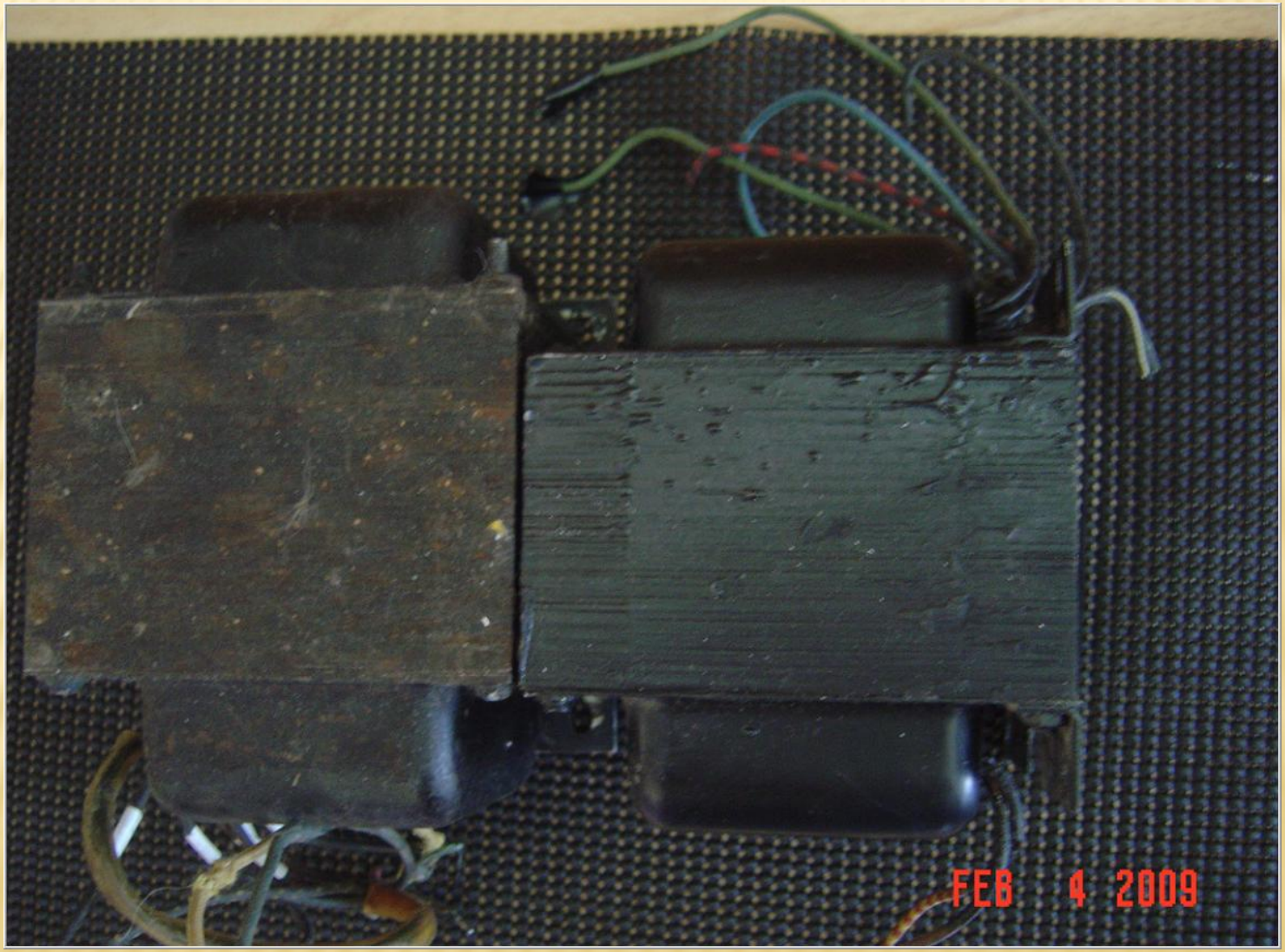
Next Step

SB220 TRANSFORMER ADVENTURE

TRANSFORMER PLAN

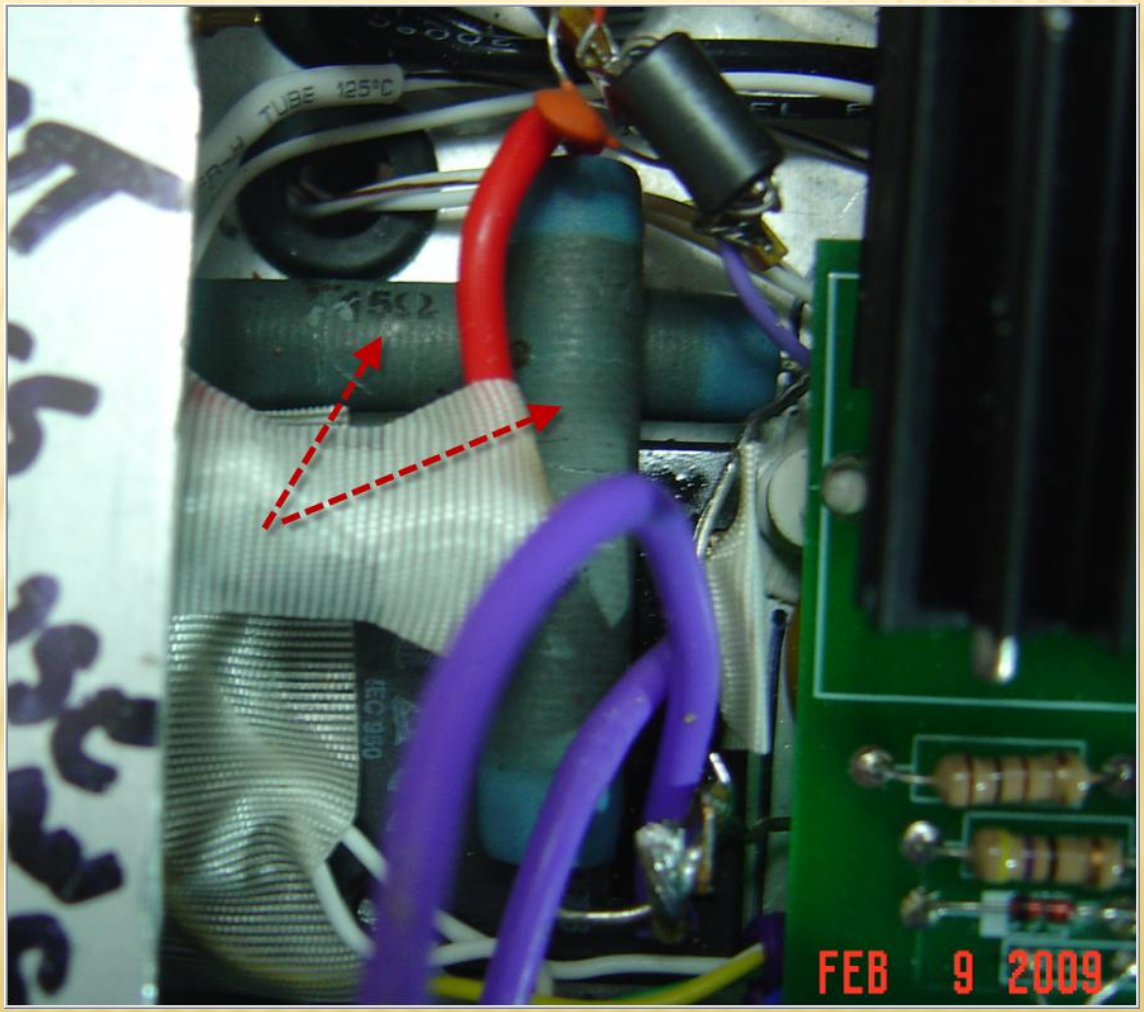
- Transformer from SB220
- Specs
  - 2KW input
  - 1150vac secondary
  - 0.8A – ICAS?
  - 19 lbs weight
- Performance
  - B+ 3100v idle
  - B+ 2800v loaded

SB200 VS. SB220 – SIZE COMPARISON

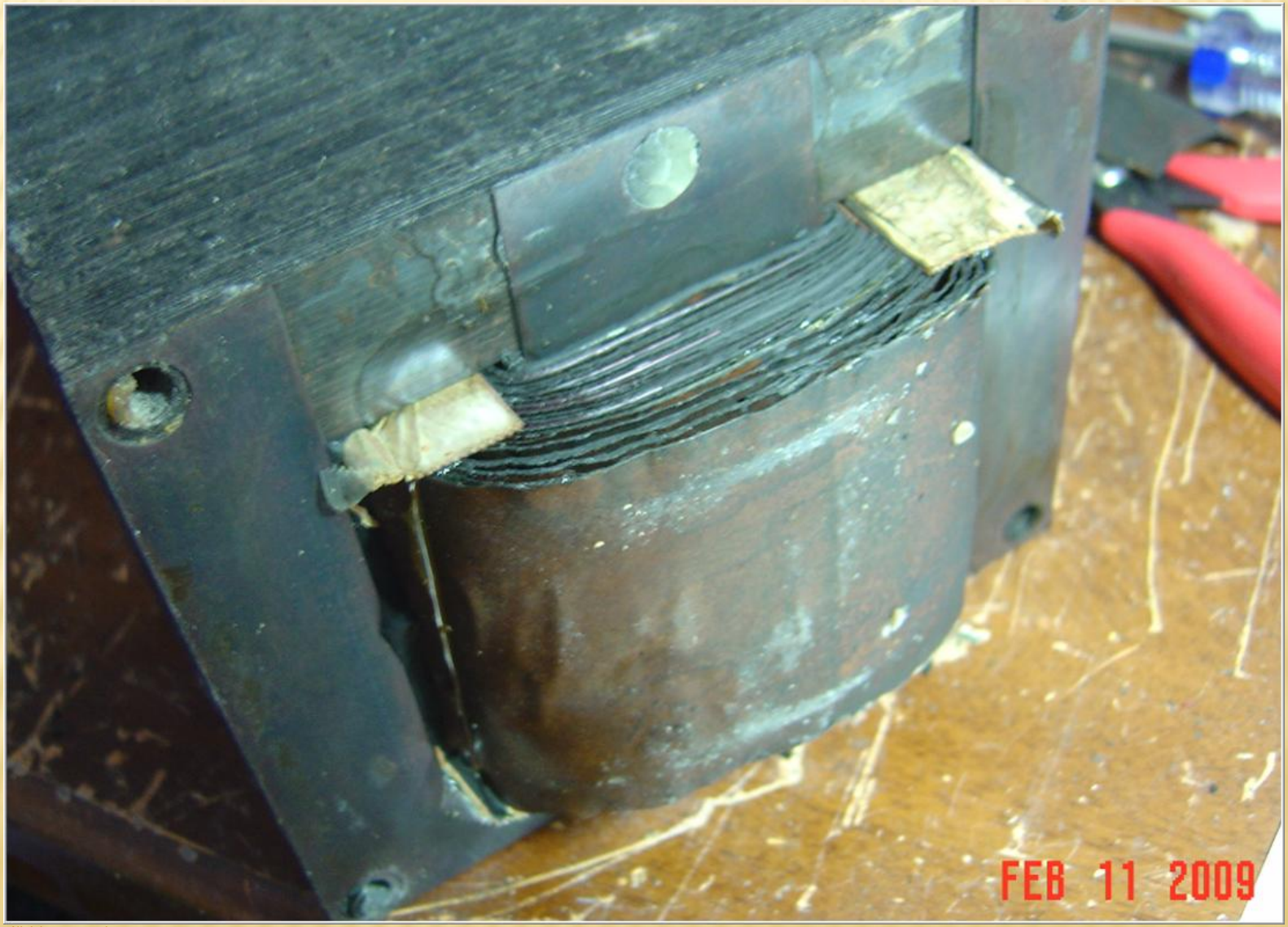


NOW THAT'S A SMOKE TEST

FRIED: STEP START RESISTORS



SB220 TX - DIED A FAST DEATH



SB220 TX – BODY COUNT

Spent most of the time today trying to get the various major problems rectified from the first test day and the exploding transformer.

Quite a bit of stuff screwed up. The body count included:

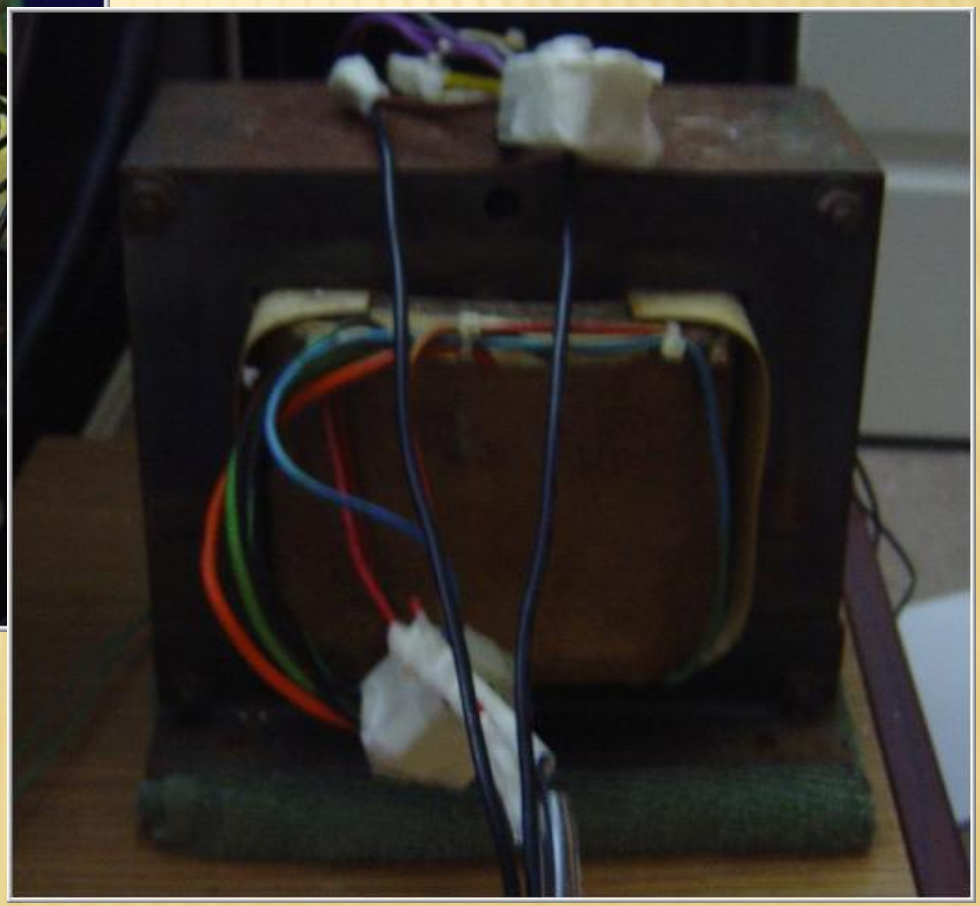
- Ig zener
- FET switch
- SS relay resistor
- 2 design errors, at least they look that way to me – fixed
- 2 DVM dead (part of the alpha tx checkout – hea, guess what, that 750v ac mark on the dvm – they really do mean it!) including my 25 year old Fluke 77

TRANSFORMER – PLAN B

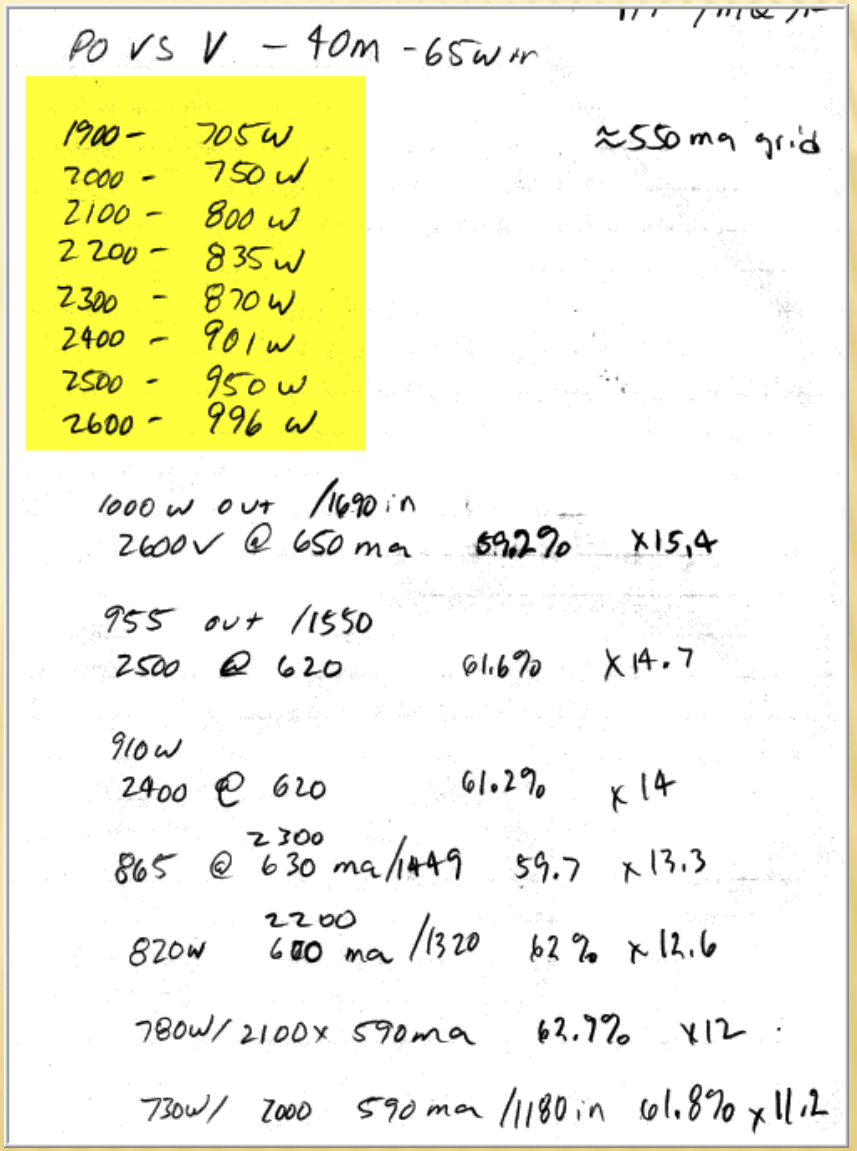
TRANSFORMER – ON TO PLAN B…

- Alpha 77pa TX
- 1100v @ 1A + capability
- With added variac – plate voltage adjustable from 1500v – 3500v
- Easy testing of amp parameters at any B+ level
- Far too large to fit inside SB200 case

VARIABLE B+ SUPPLY



POWER OUTPUT VS. PLATE VOLTAGE


PO vs V – 40m – 65w ar

1900 – 705w
2000 – 750w
2100 – 800w
2200 – 835w
2300 – 870w
2400 – 901w
2500 – 950w
2600 – 996w

≈550 ma grid

1000w out /1690 in
2600v @ 650 ma 59.2% x15.4

955 out /1550
2500 @ 620 61.6% x14.7

910w
2400 @ 620 61.2% x14

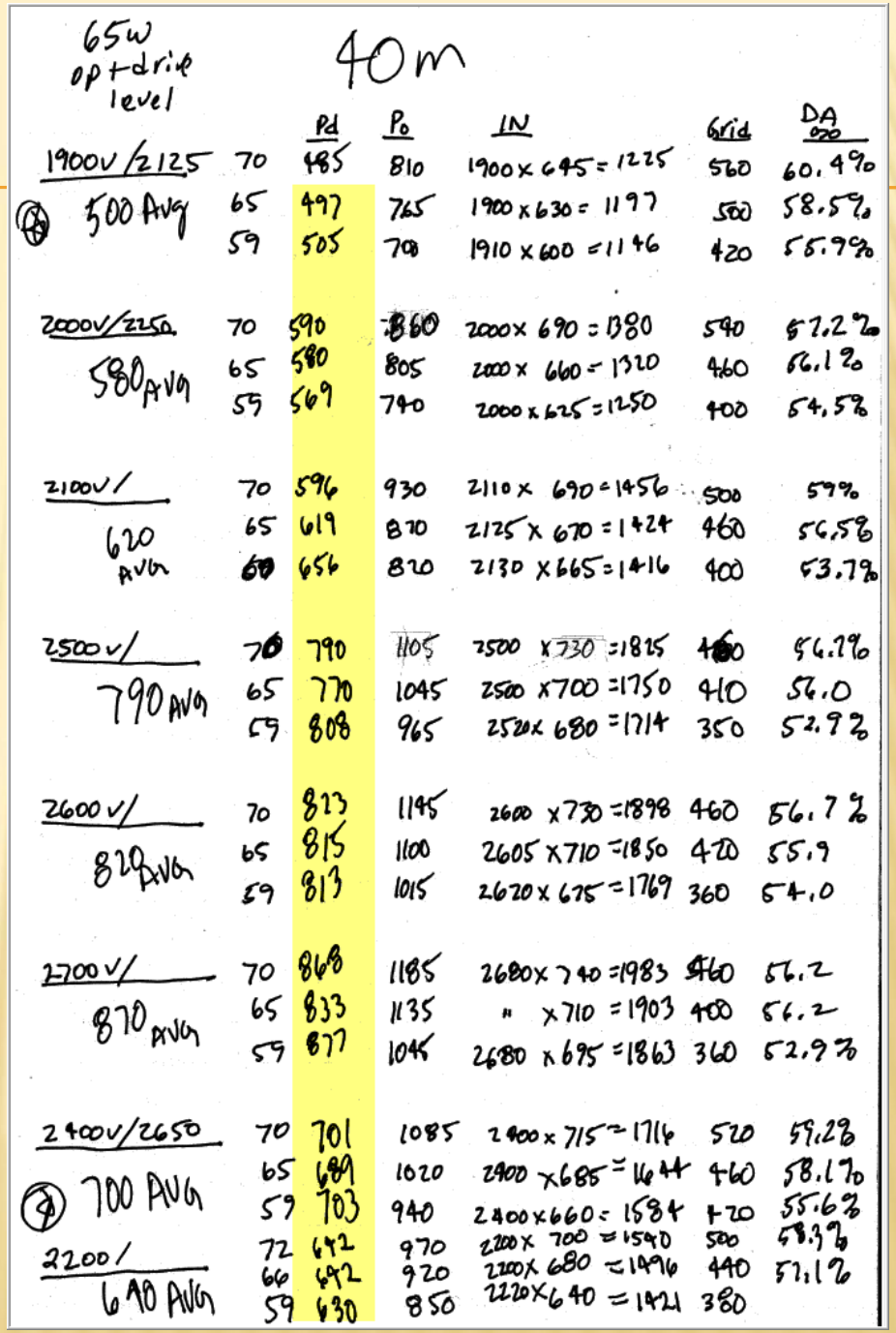
865 @ 2300 630 ma/1449 59.7 x13.3

820w 2200 600 ma /1320 62% x12.6

780w/ 2100 x 590ma 62.7% x12

730w/ 2000 590 ma /1180 in 61.8% x11.2

PLATE DISIPATION DETERMINED PRIMARLY BY PLATE VOLTAGE

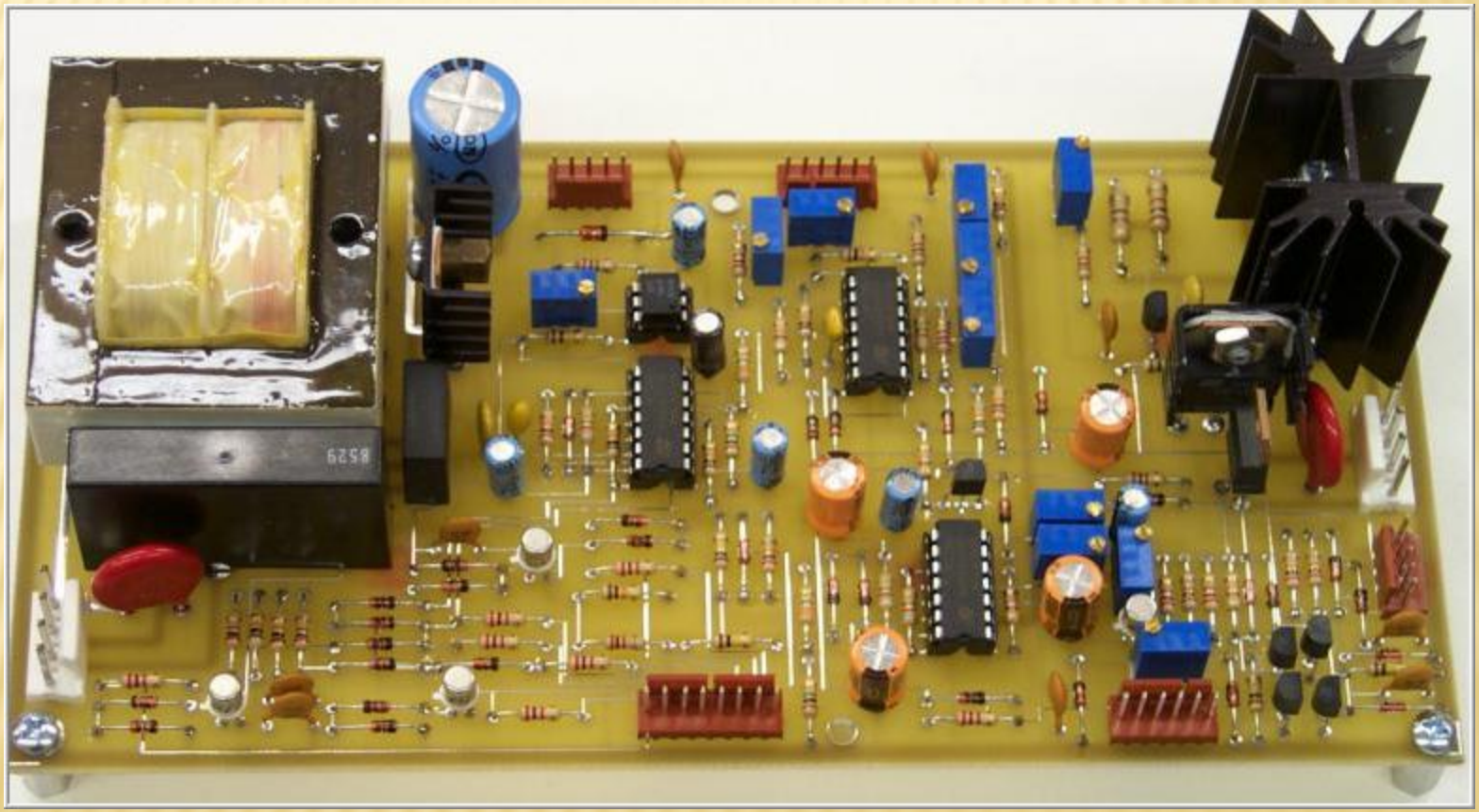


65W op+drive level — 40m

		Pd	Po	IN	Grid	DA 020
1900V/2125	70	485	810	1900 x 645 = 1225	560	60.4%
⑧ 500 Avg	65	497	765	1900 x 630 = 1197	500	58.5%
	59	505	700	1910 x 600 = 1146	420	55.9%
2000V/2250	70	590	860	2000 x 690 = 1380	540	57.2%
580 AVG	65	580	805	2000 x 660 = 1320	460	56.1%
	59	569	740	2000 x 625 = 1250	400	54.5%
2100V/	70	596	930	2110 x 690 = 1456	500	59%
620 AVG	65	619	870	2125 x 670 = 1424	460	56.5%
	60	656	820	2130 x 665 = 1416	400	53.7%
2500V/	70	790	1105	2500 x 730 = 1825	480	56.7%
790 AVG	65	770	1045	2500 x 700 = 1750	410	56.0
	59	808	965	2520 x 680 = 1714	350	52.9%
2600V/	70	823	1195	2600 x 730 = 1898	460	56.7%
829 AVG	65	815	1100	2605 x 710 = 1850	420	55.9
	59	813	1015	2620 x 675 = 1769	360	54.0
2700V/	70	868	1185	2680 x 740 = 1983	460	56.2
870 AVG	65	833	1135	" x 710 = 1903	400	56.2
	59	877	1045	2680 x 695 = 1863	360	52.9%
2400V/2650	70	701	1085	2400 x 715 = 1716	520	59.2%
⑧ 700 AVG	65	689	1020	2400 x 685 = 1644	460	58.1%
	59	703	940	2400 x 660 = 1584	420	55.6%
2200/	72	692	970	2200 x 700 = 1540	500	58.3%
690 AVG	66	692	920	2200 x 680 = 1496	440	57.1%
	59	630	850	2220 x 640 = 1421	380	

BRAINS

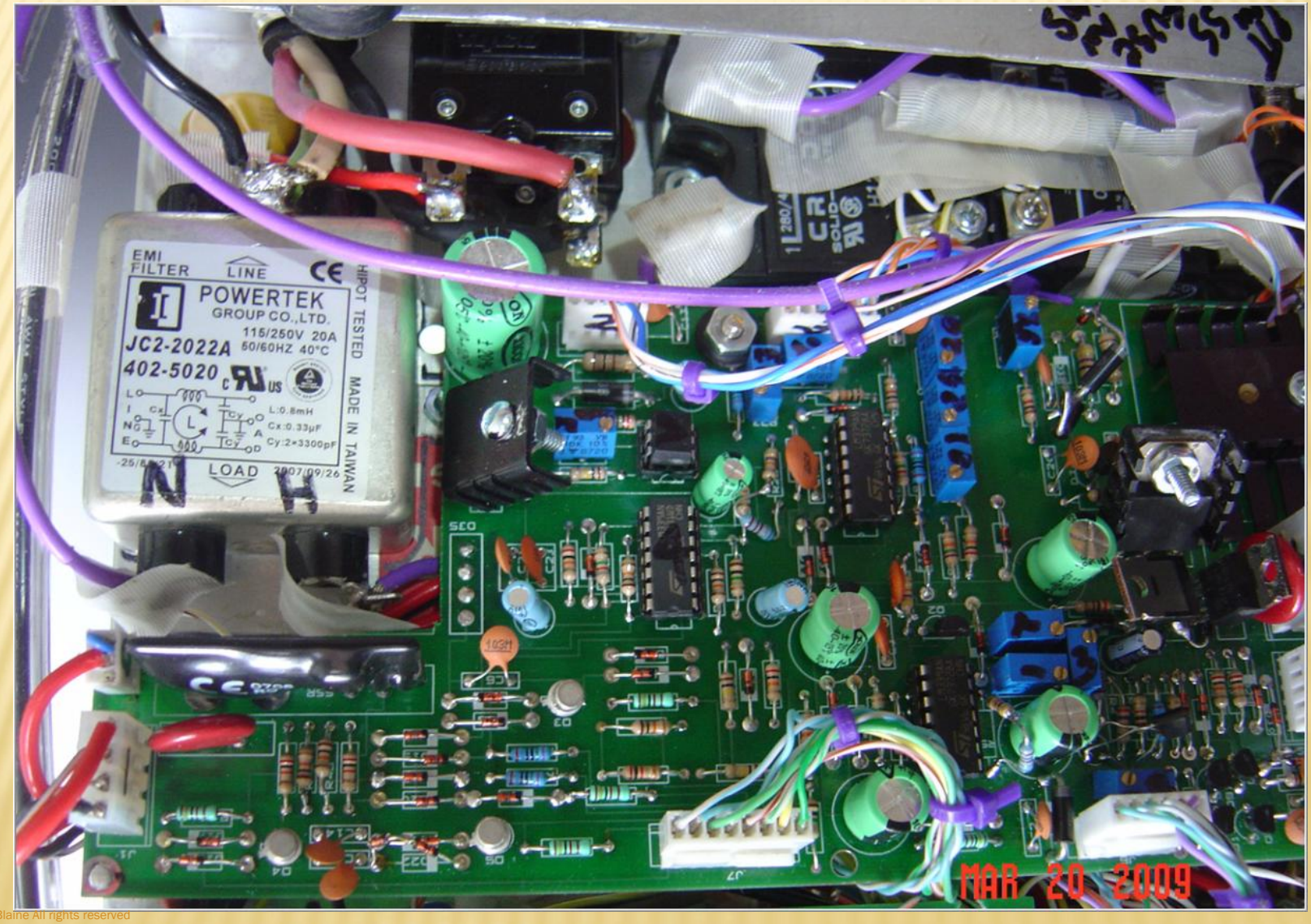
WD7S TRIODE CONTROL BOARD



WD7S TRIODE CONTROL BOARD

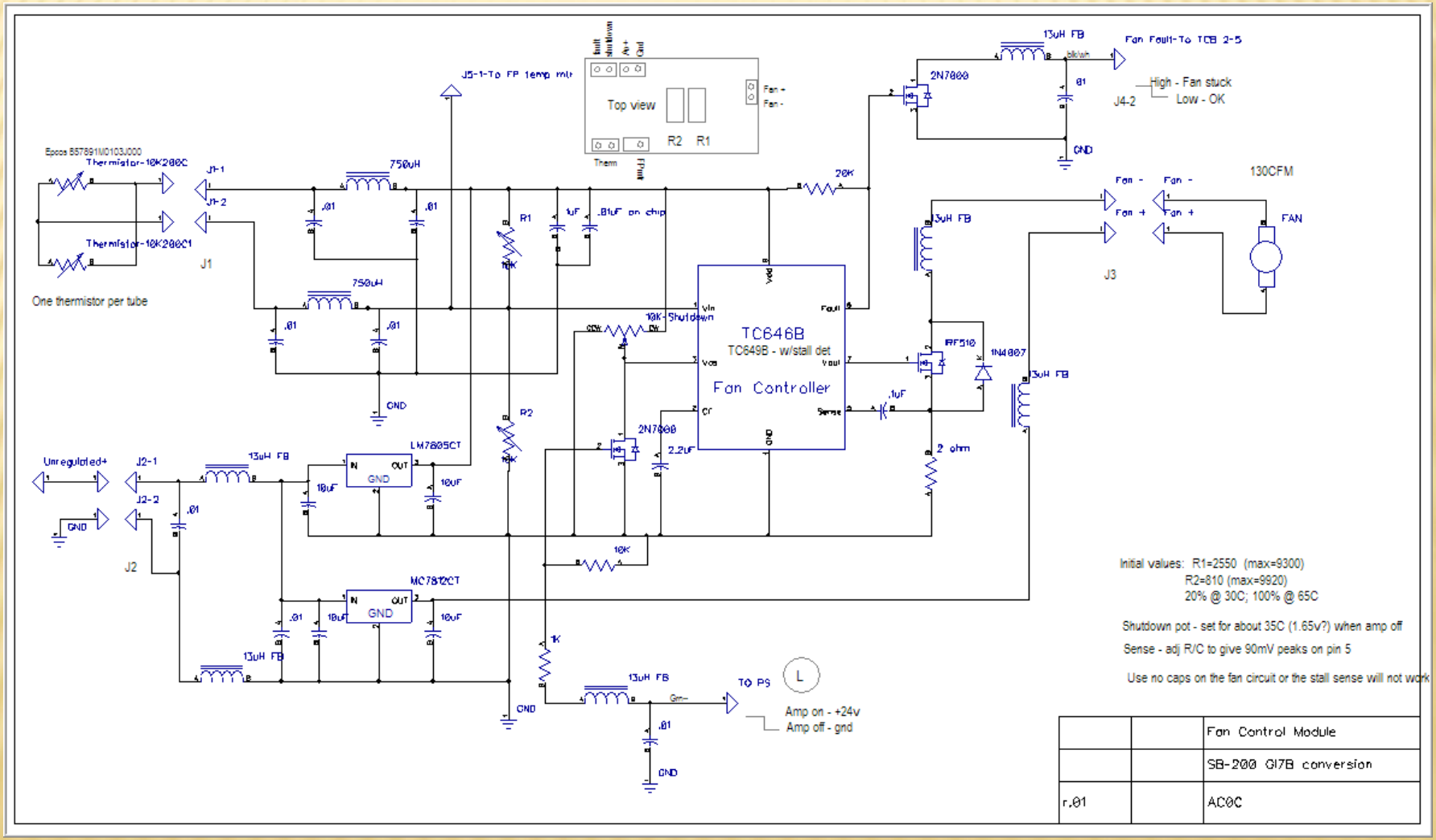
- ADJUSTABLE WARM-UP TIMER
- ADJUSTABLE GRID OVER-CURRENT FAULT, AUTO-RESET
- ADJUSTABLE GRID OVER-CURRENT WARNING LED
- ADJUSTABLE PLATE OVER-CURRENT FAULT, SHUTS DOWN HV SUPPLY IN 8.3 mS
- STEP-START HV TURN ON
- TUNE/ARC, HV and AIR FAULT
- FULL BREAK-IN QSK - LESS THAN 2.1 MS
- T/R FAULT, TRANSFER RELAY HOT SWITCHING PROTECTION
- FULLY ADJUSTABLE OPERATING BIAS USING THE TL-431 ADJUSTABLE PRECISION REFERENCE
- SOLID STATE BIAS SWITCHING
- DUAL KEY-LINE BUFFERS, EITHER +5 TO +16 VDC OR GROUND WILL KEY THE AMPLIFIER
- FRONT PANEL STATUS OF ALL FAULT AND OPERATING CONDITIONS
- SOLID STATE RELAYS USED FOR ALL AC SWITCHING

WD7S TCB - TIGHT FIT - SERIOUS MODS



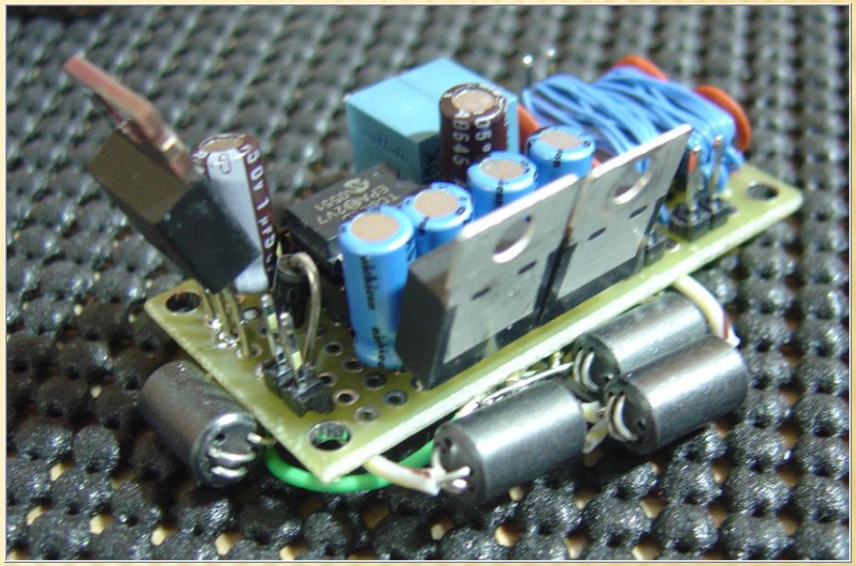
COOL AND QUIET

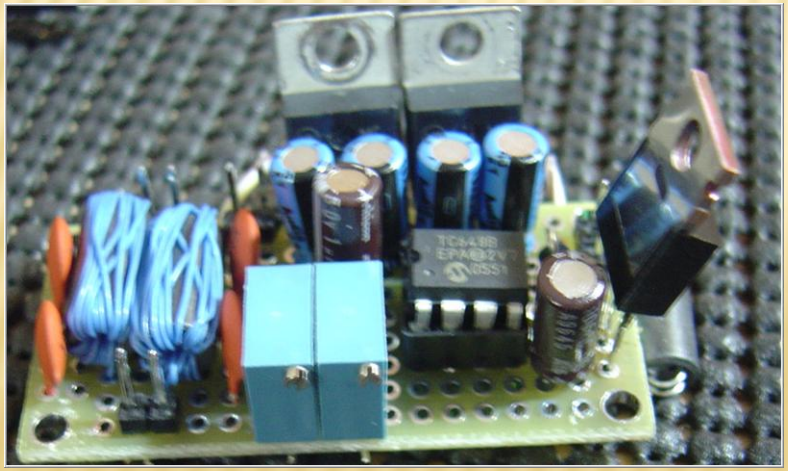
FAN CONTROL MODULE

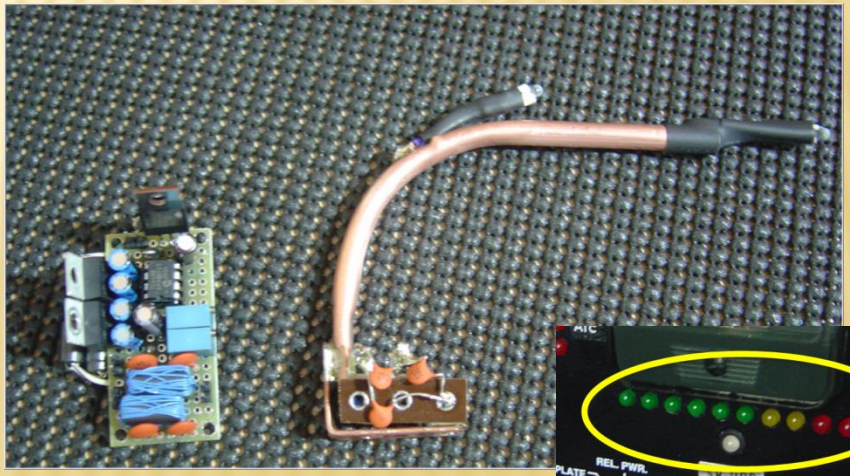


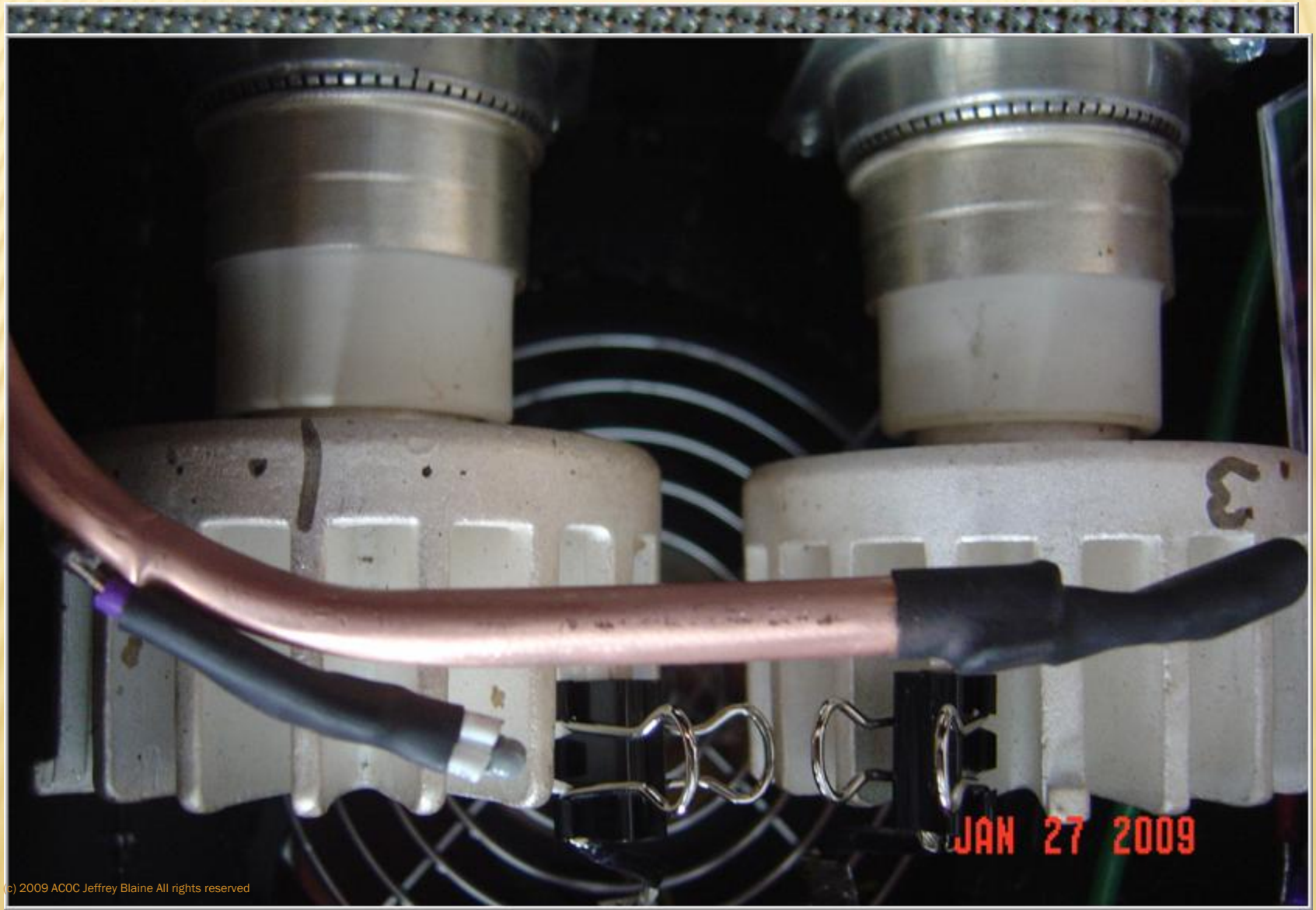
FAN CONTROL MODULE

- Varisistors over tube heatsinks control PWM DC fan speed
- Cooling/noise scale to current amp load
- Front panel bar-graph indication of heatsink temp

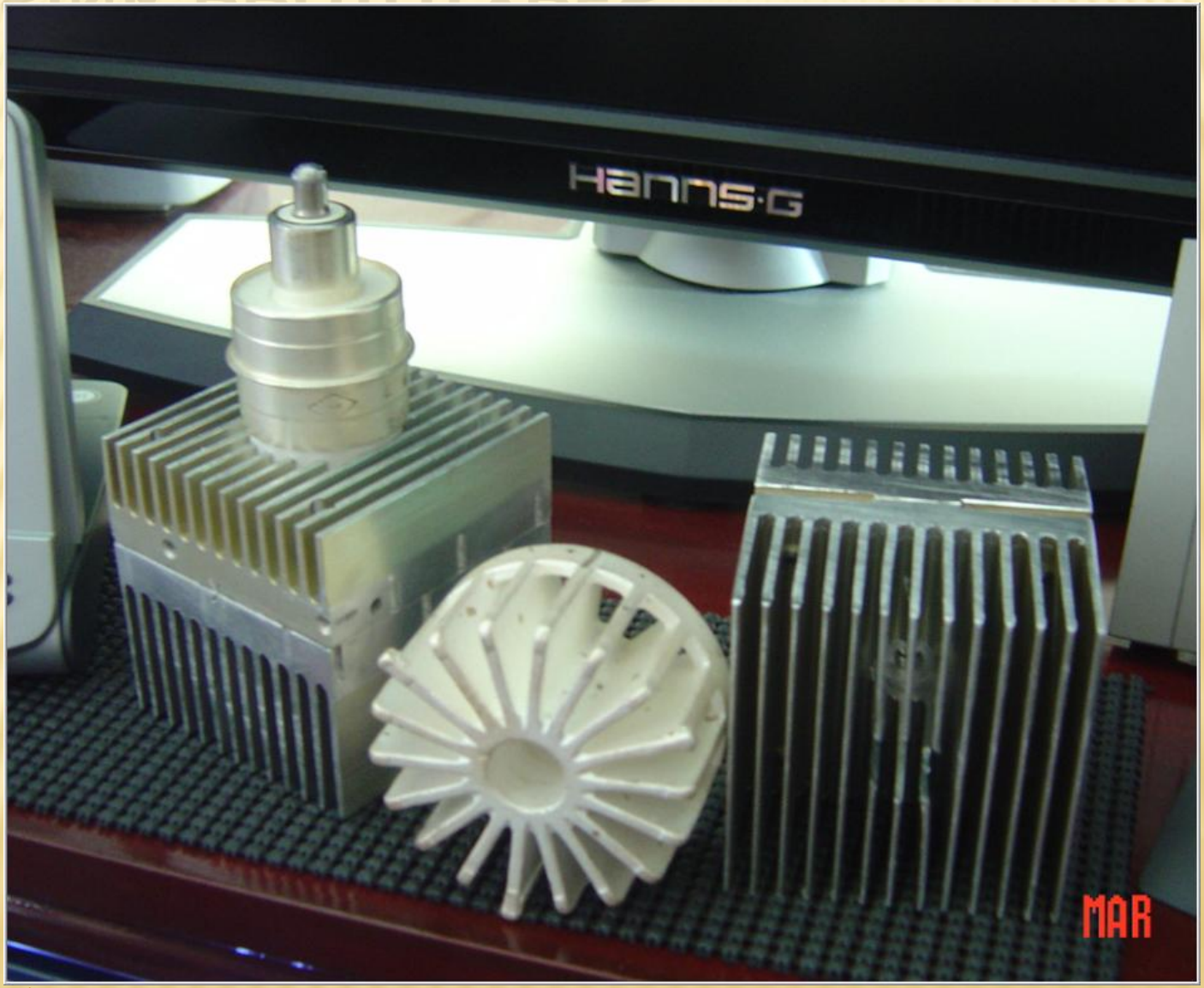




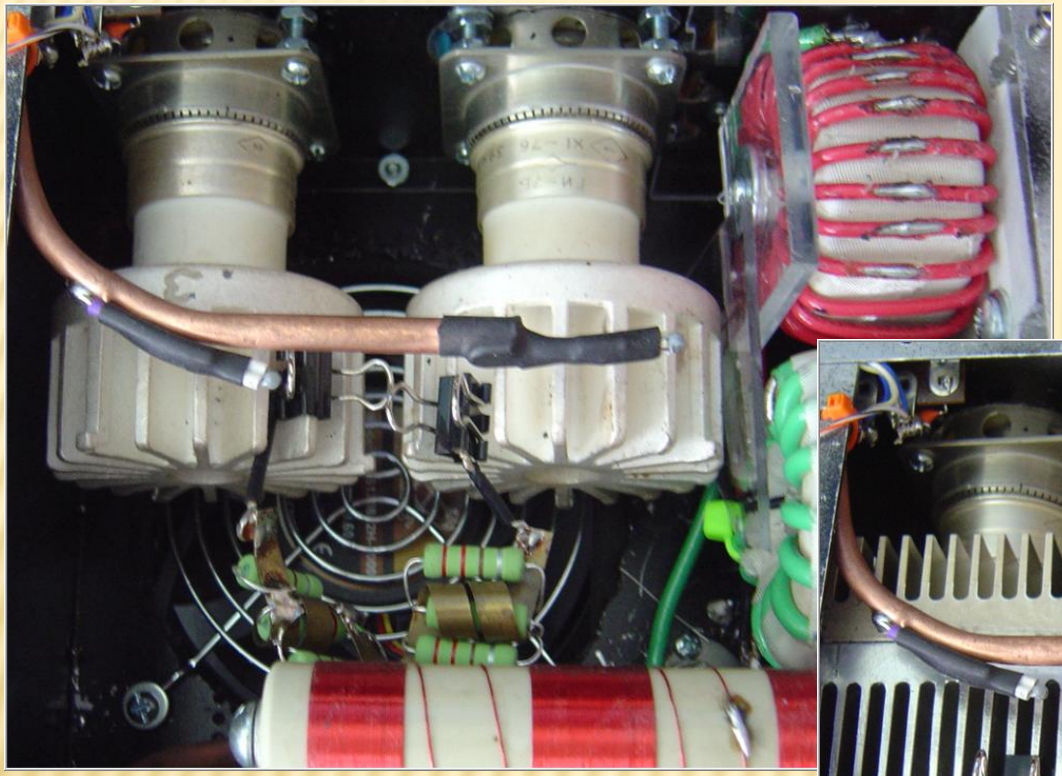


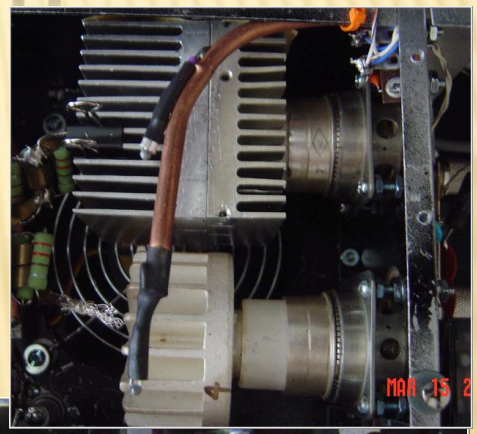


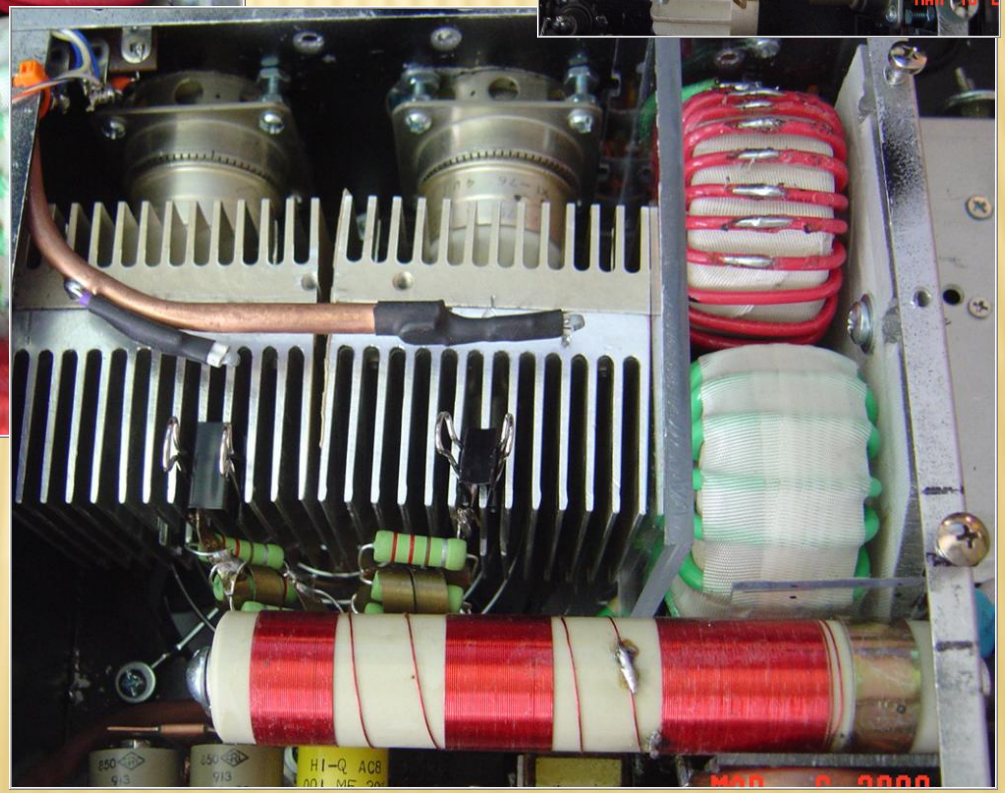
HEATSINK PROTOTYPES



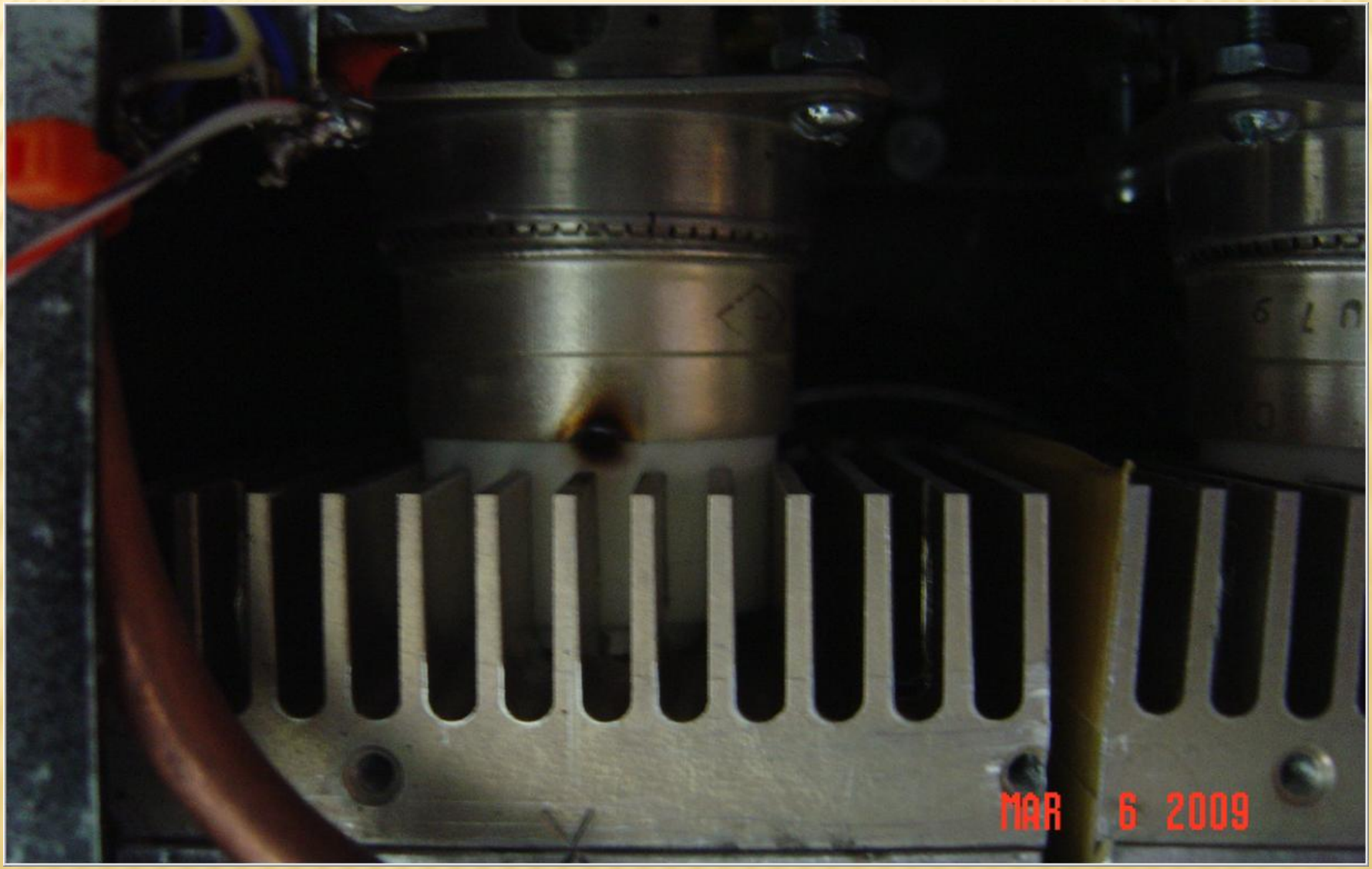
HEATSINK PROTOTYPE - TIGHT FIT



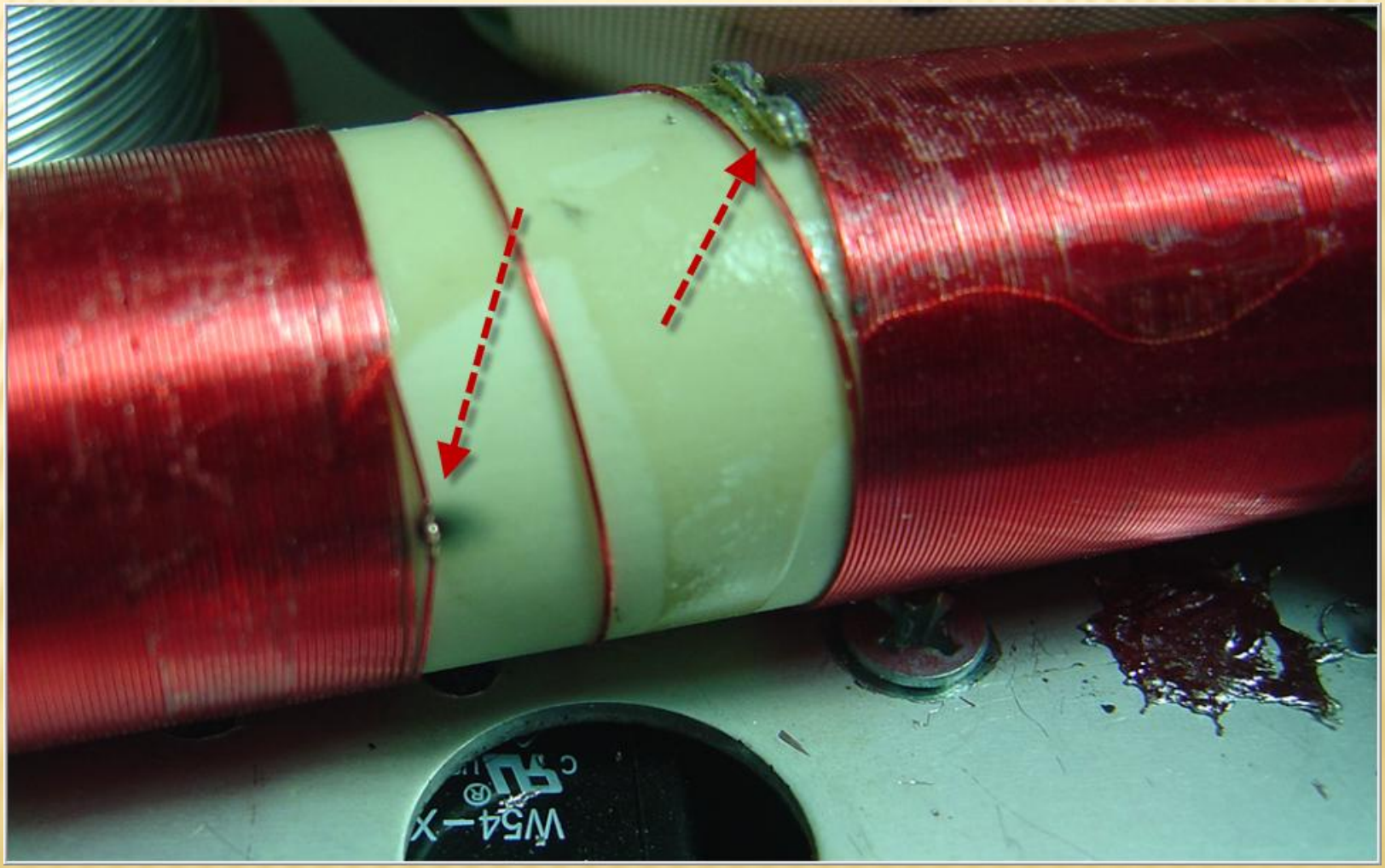




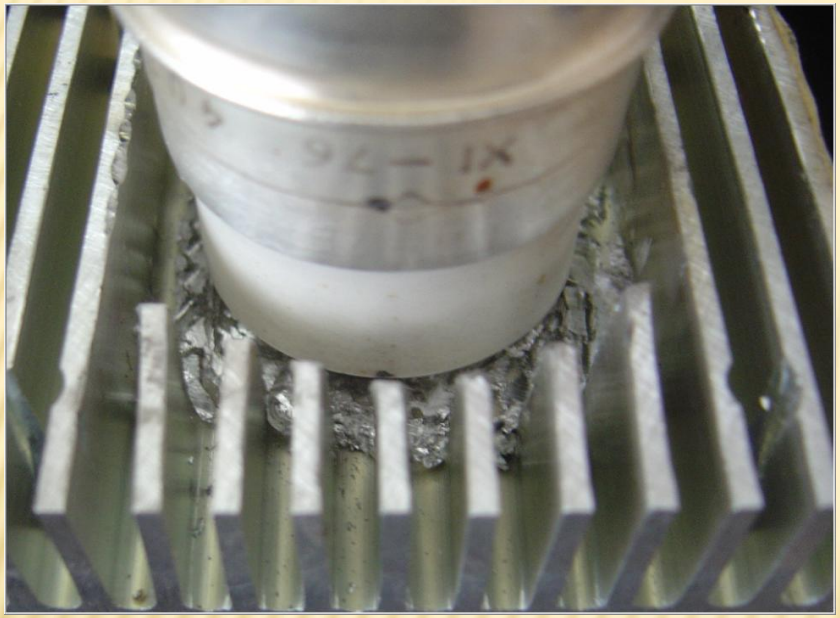
SNAP CRACKLE POP

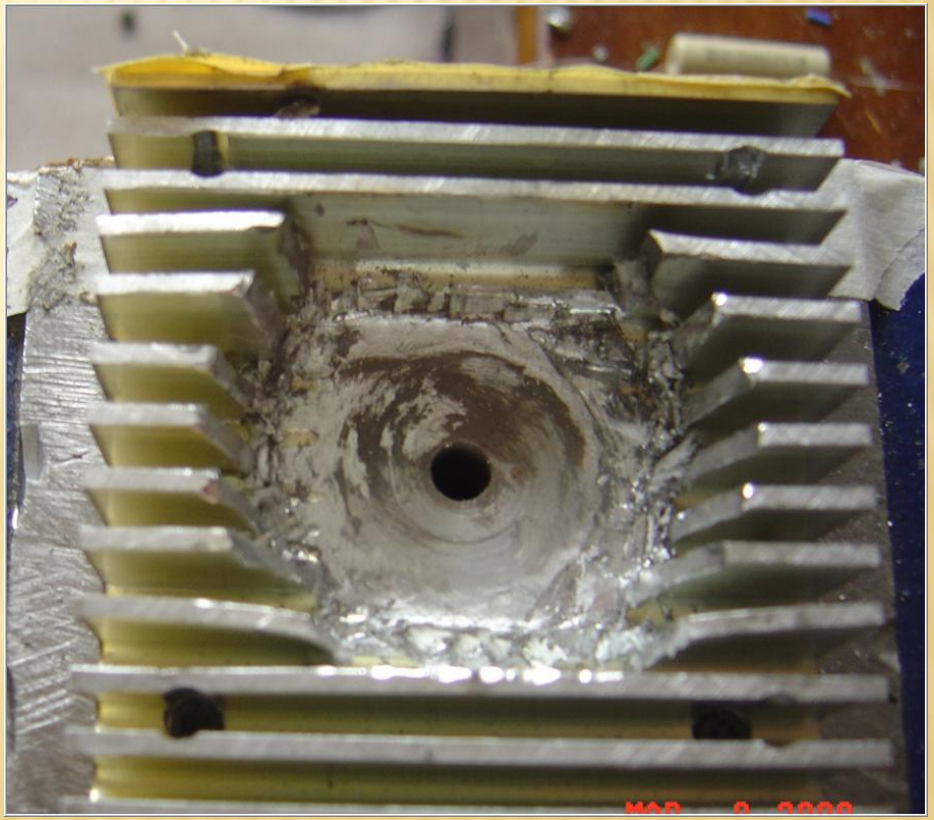


GLITCH HAMMERS PLATE CHOKE



RELEIF HACKING OF HEATSINKS



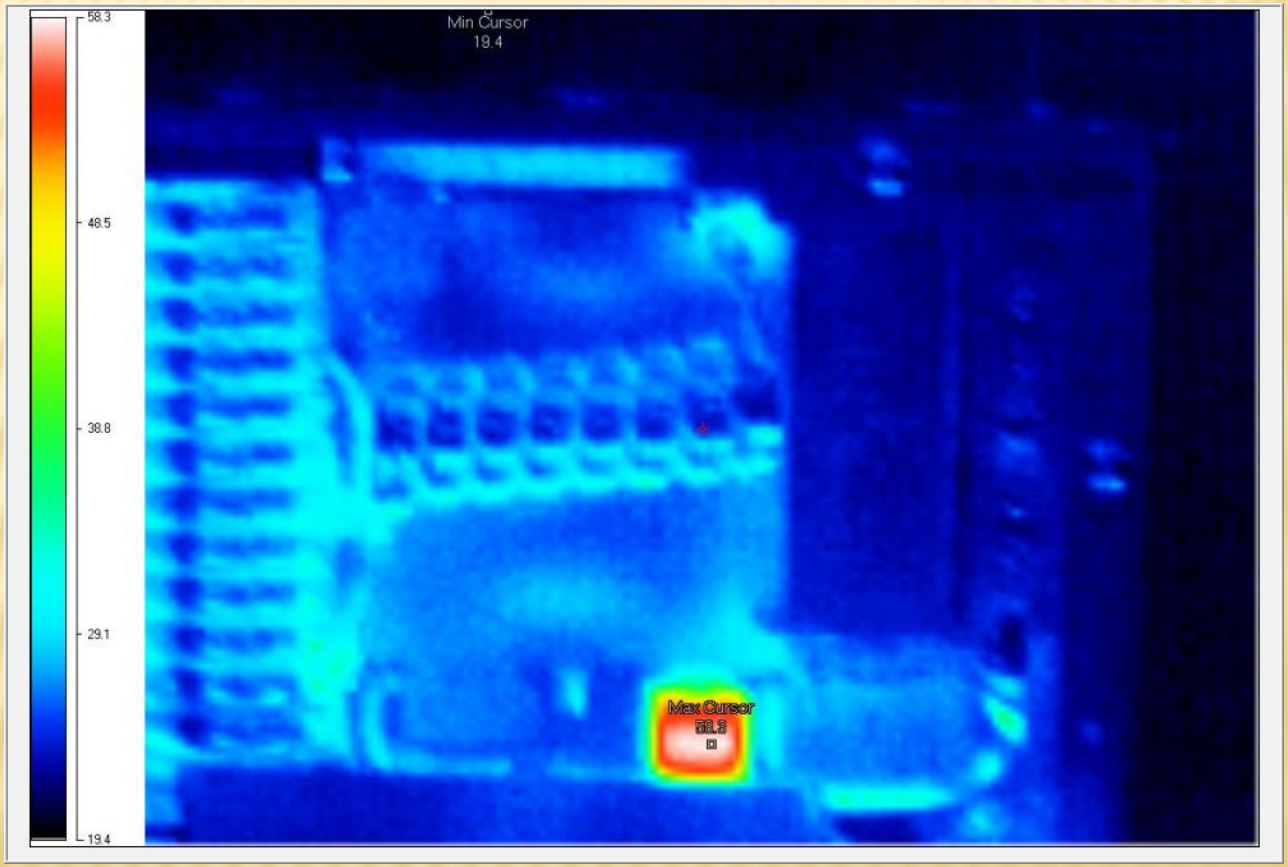


MORE DEAD SOLDERS

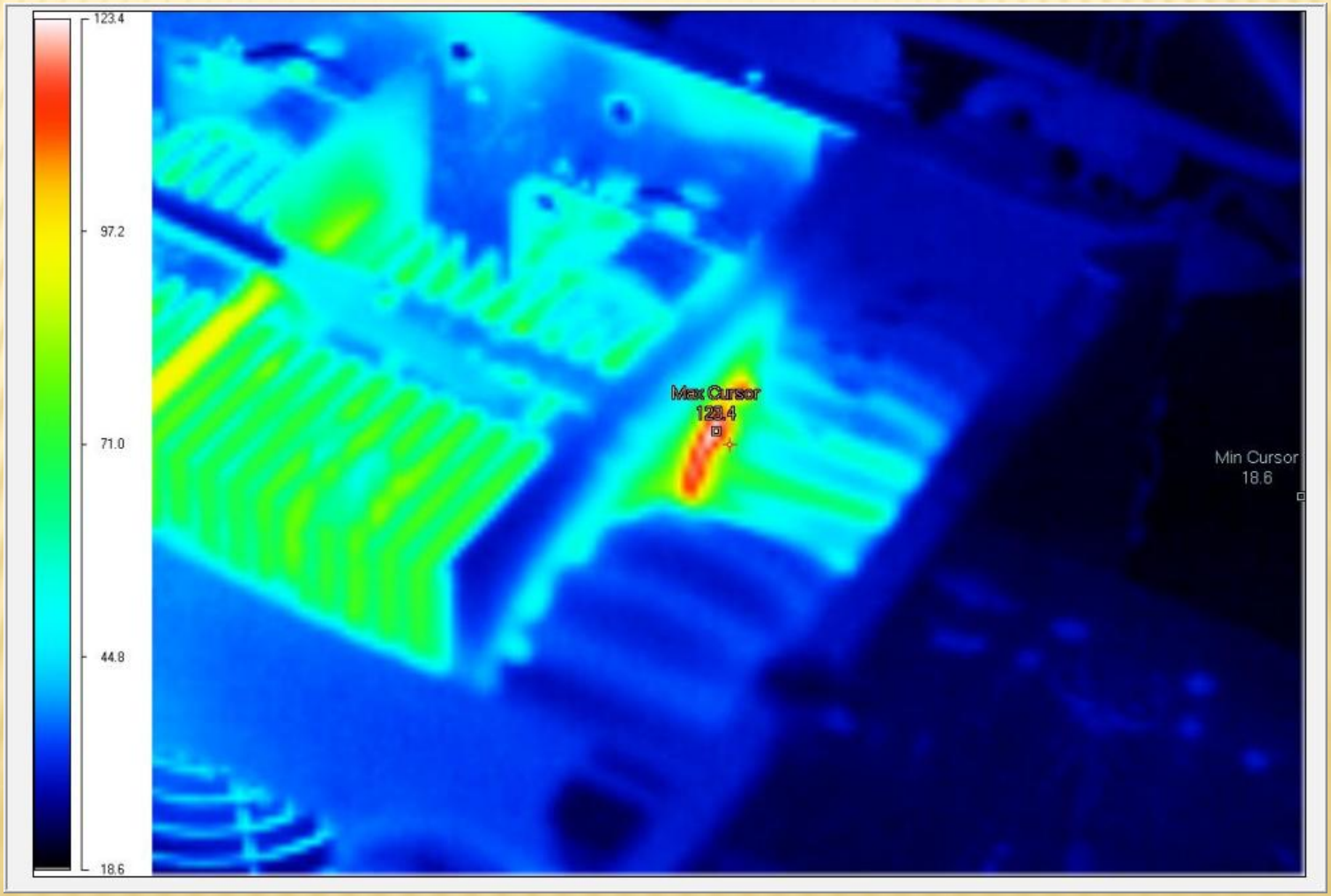
- Parasitic resistors & burned input circuits

KORU THERMAL IMAGING

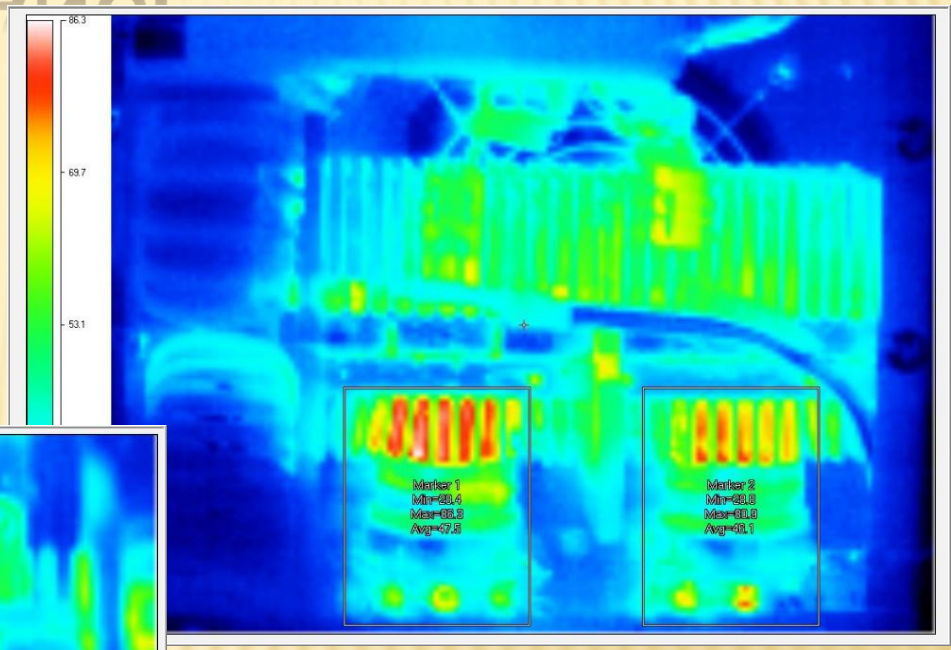
TANK COUPLING CAP

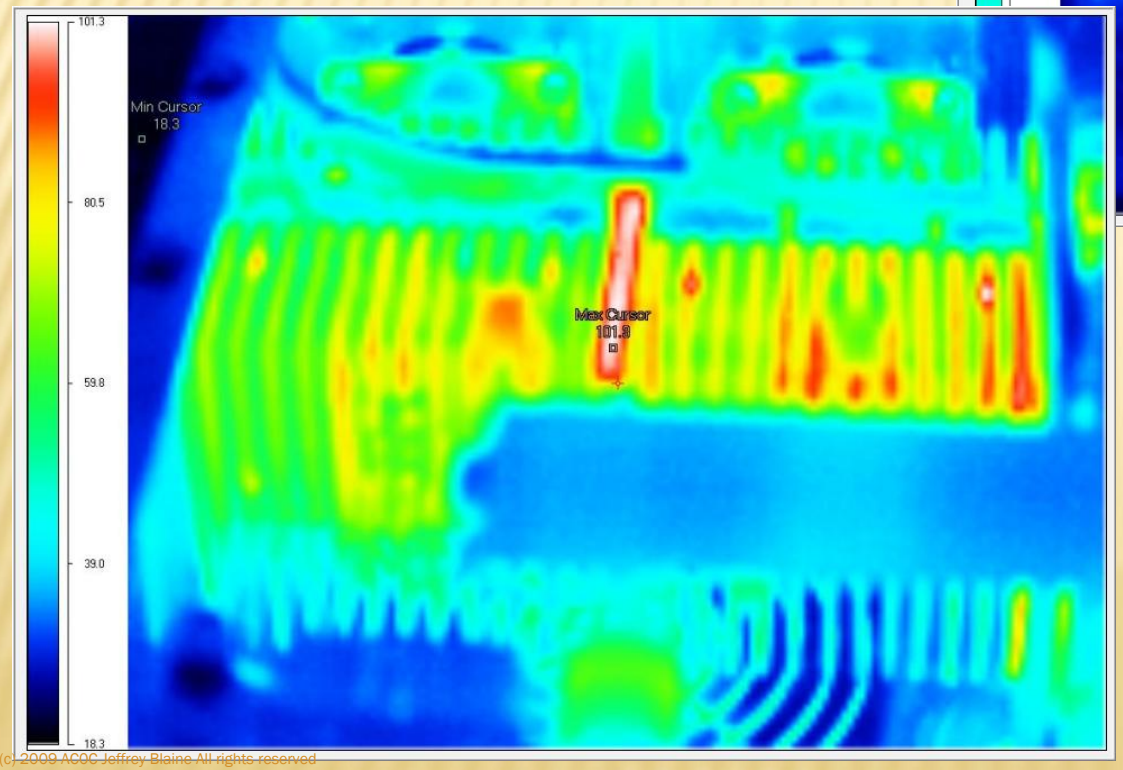


TOROID INSULATOR HOT-SPOT

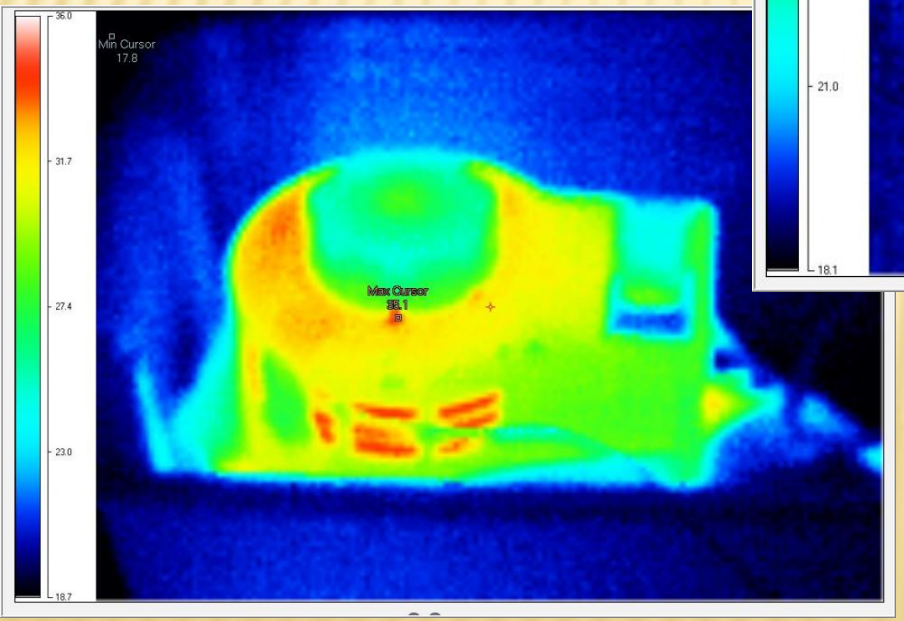


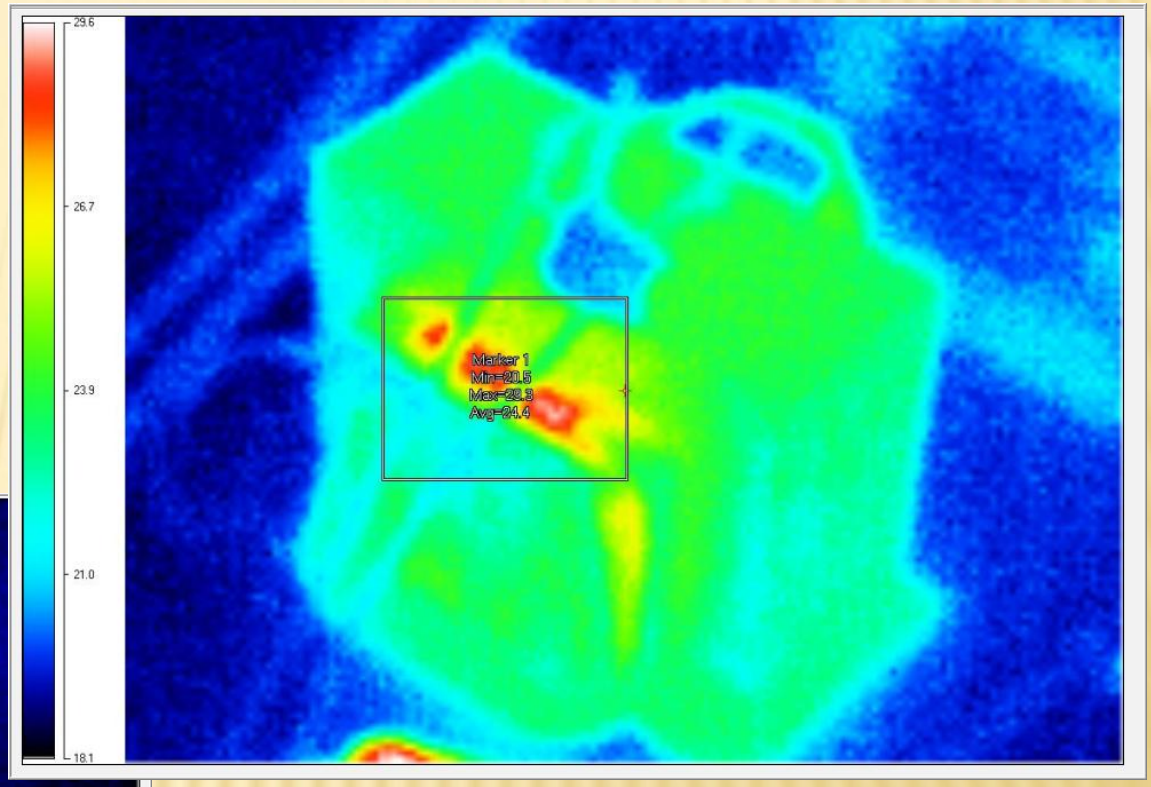
HEATSINK PERFORMANCE



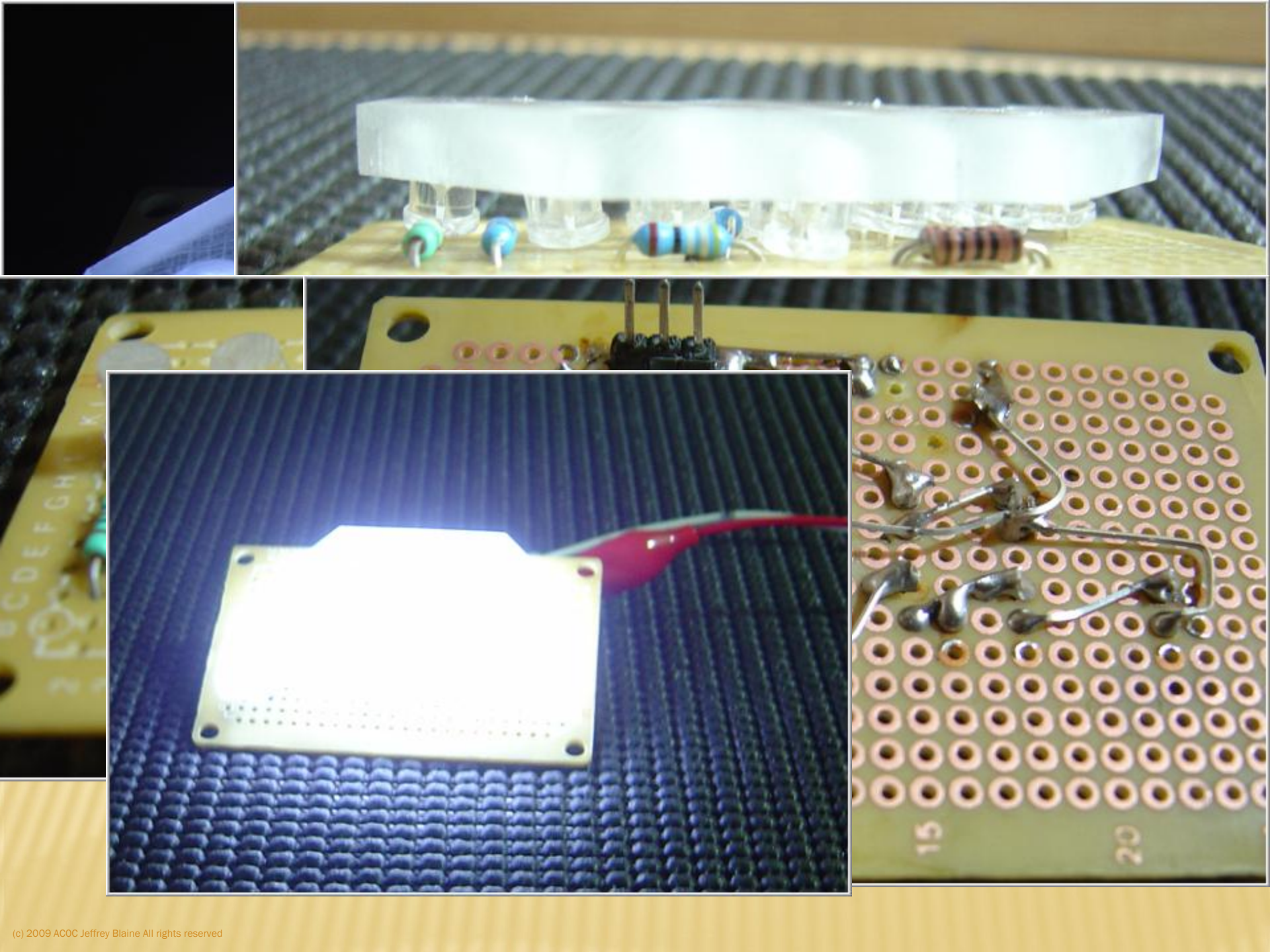


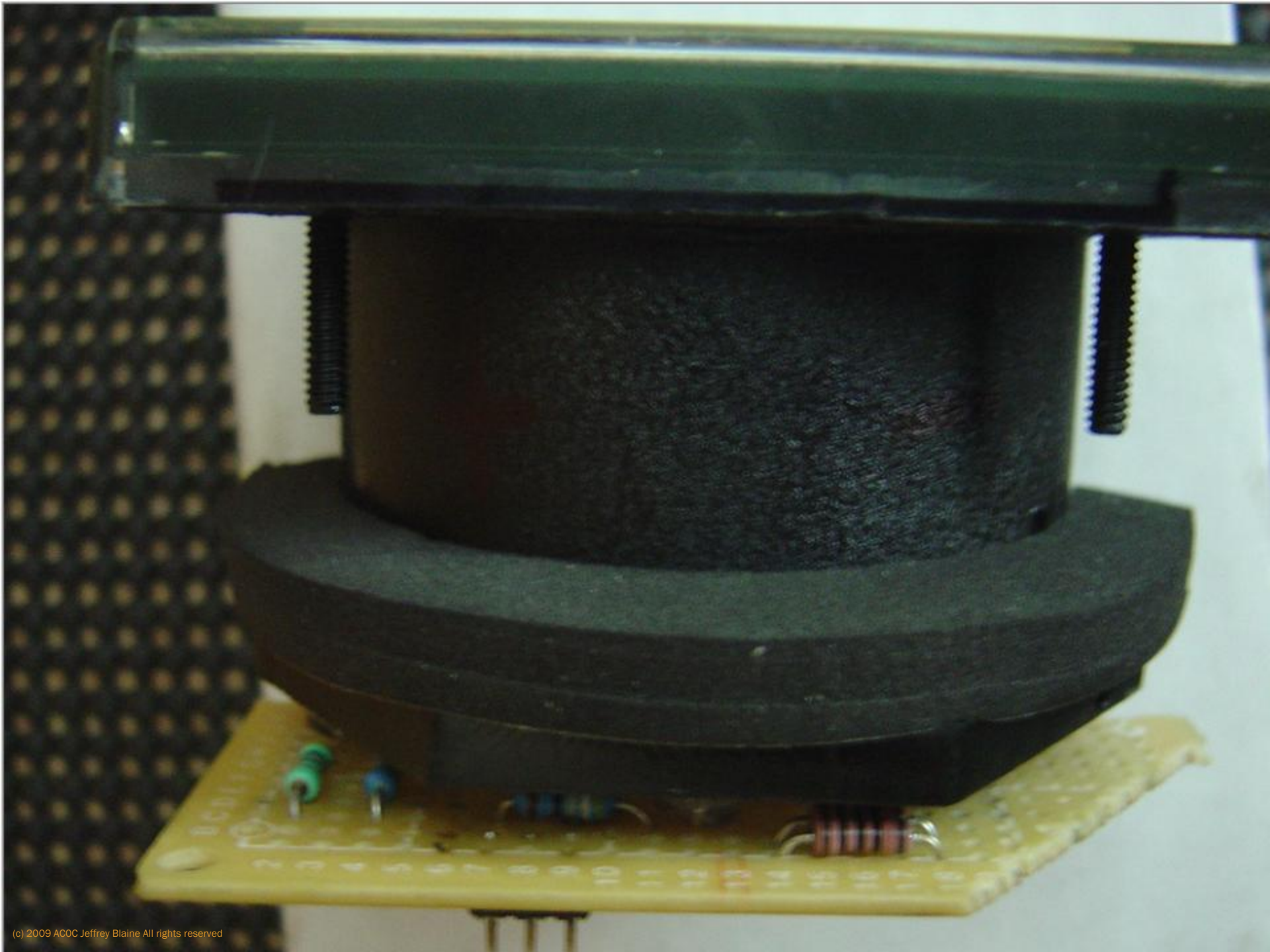
VARIAC & PLATE TX



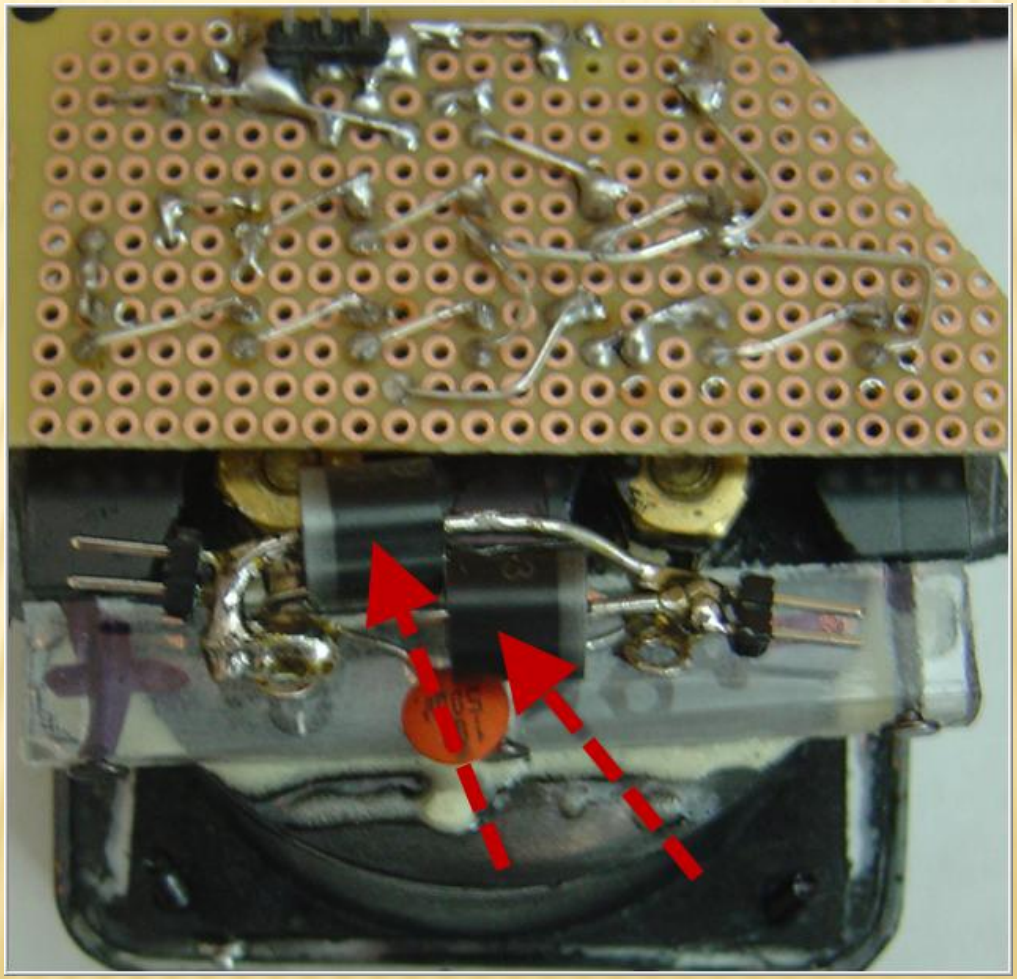


INSTRUMENTATION

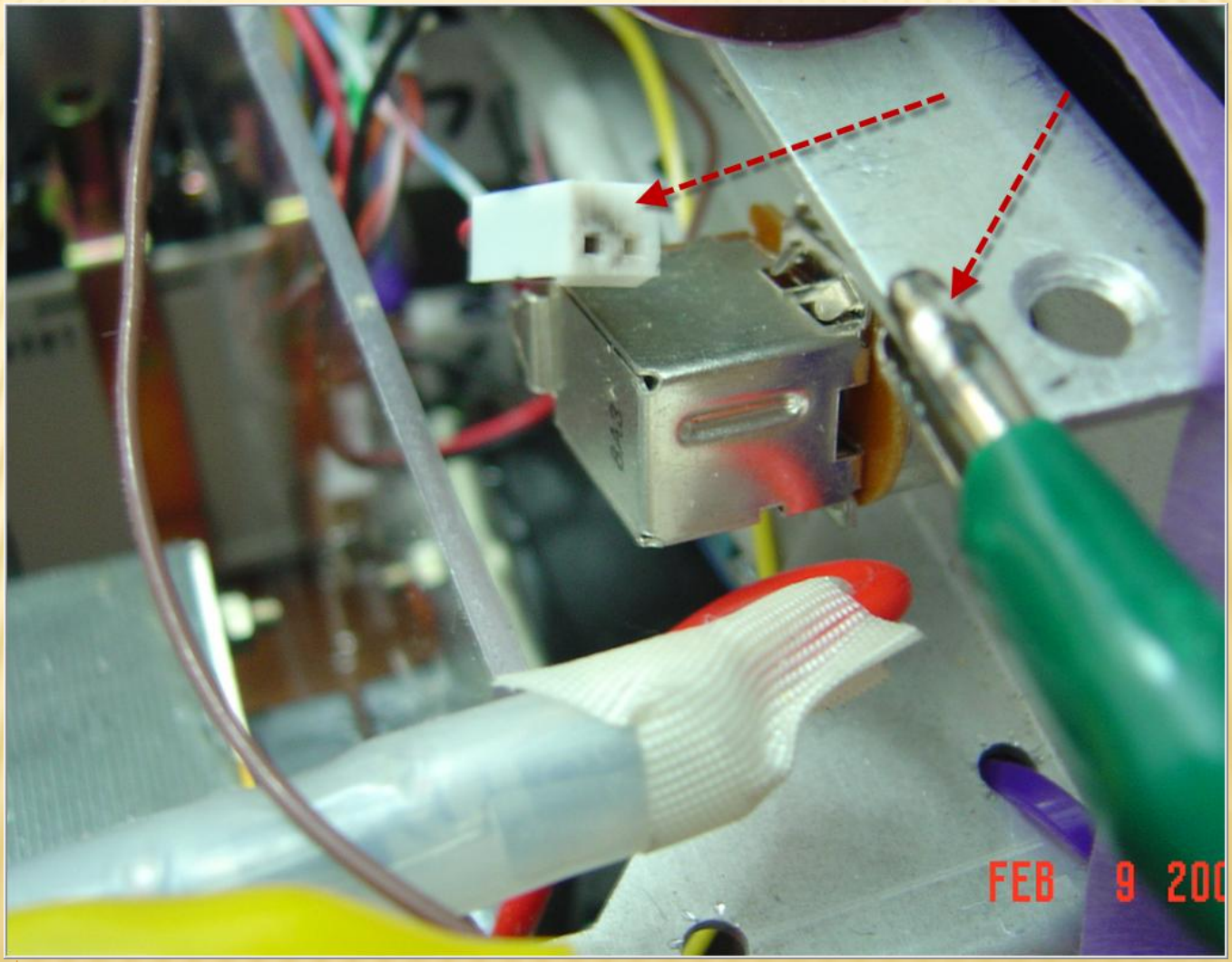


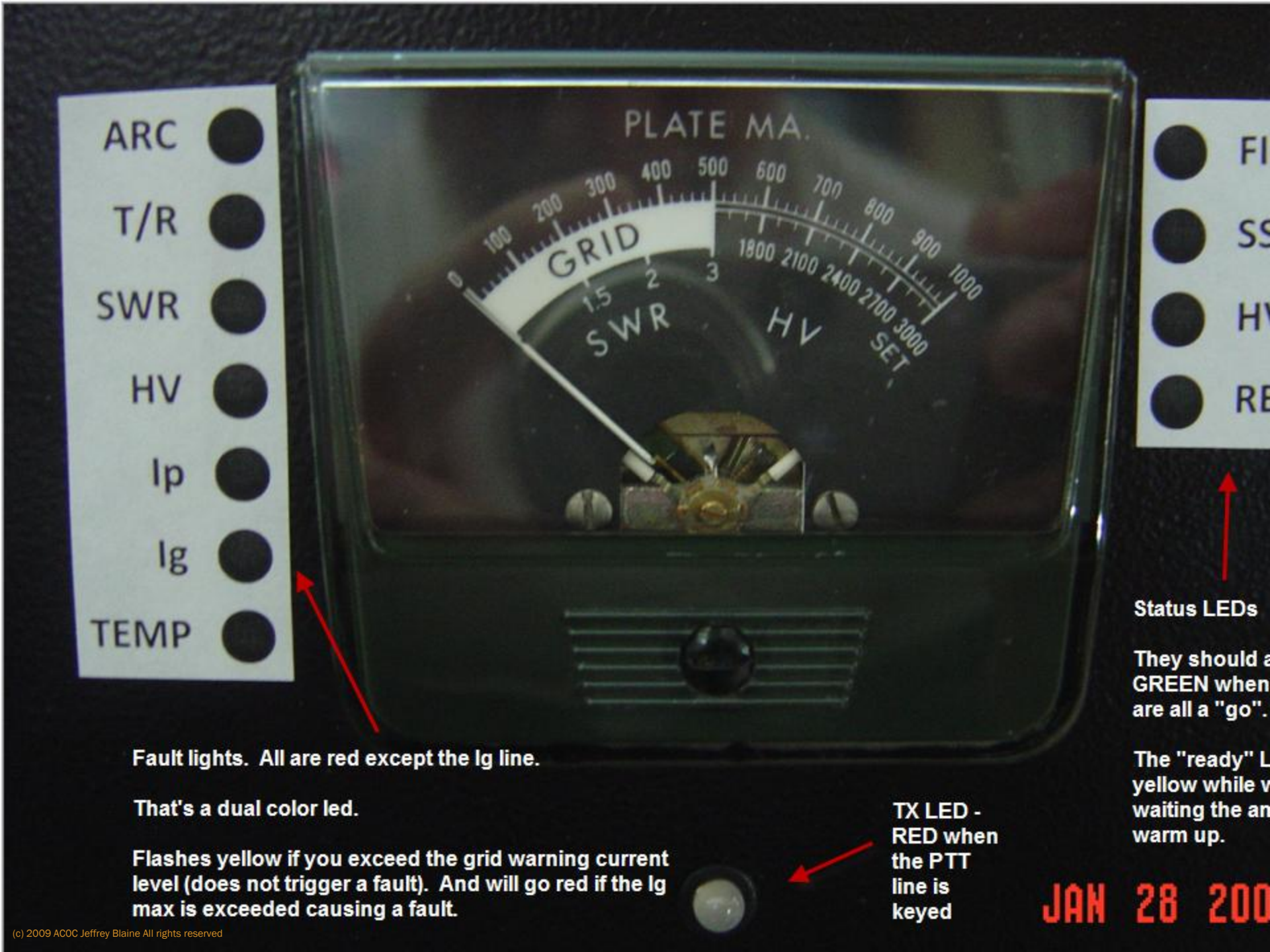


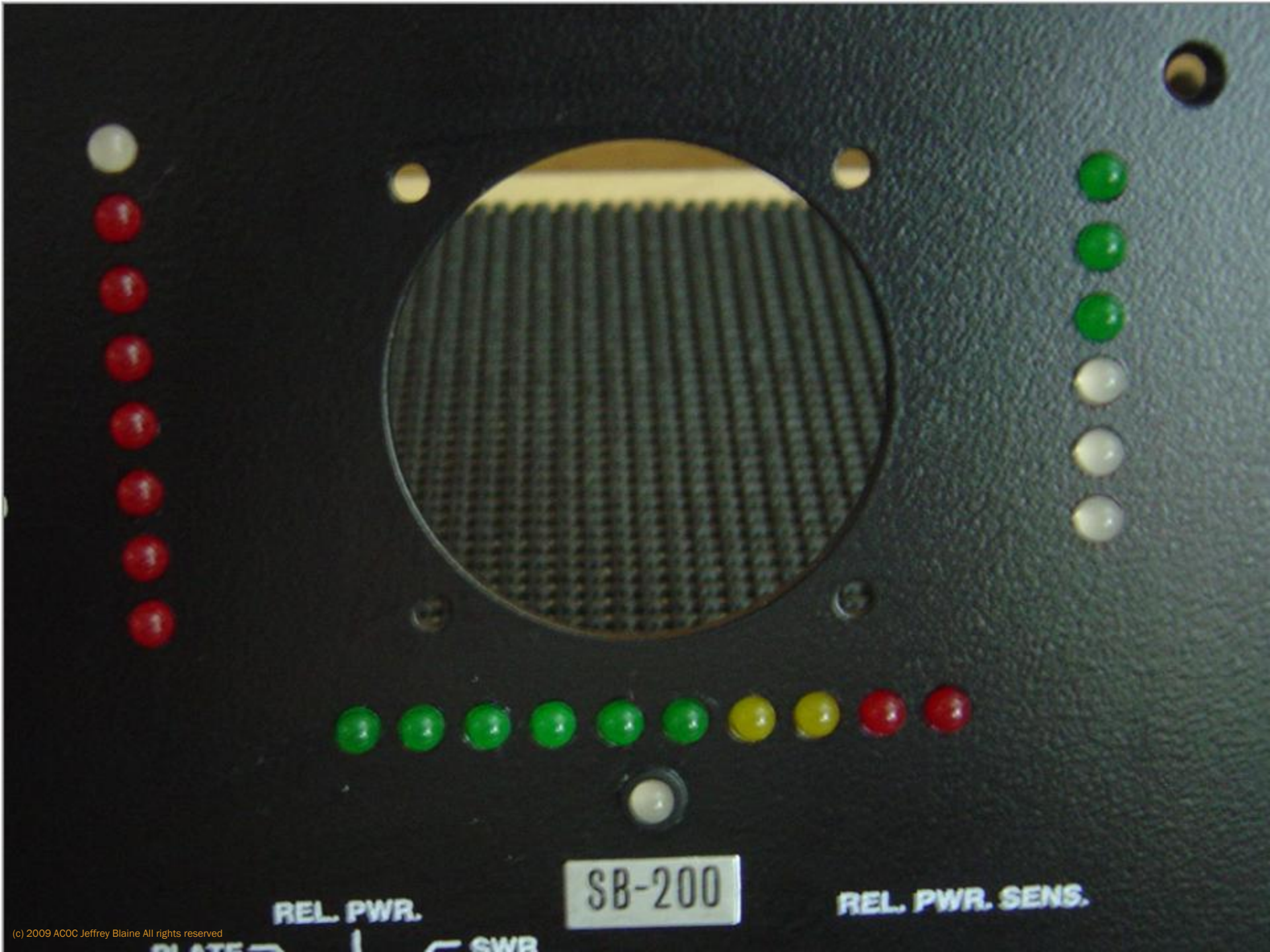
CHEAP INSURANCE – 1KV@6A-400A PEAK

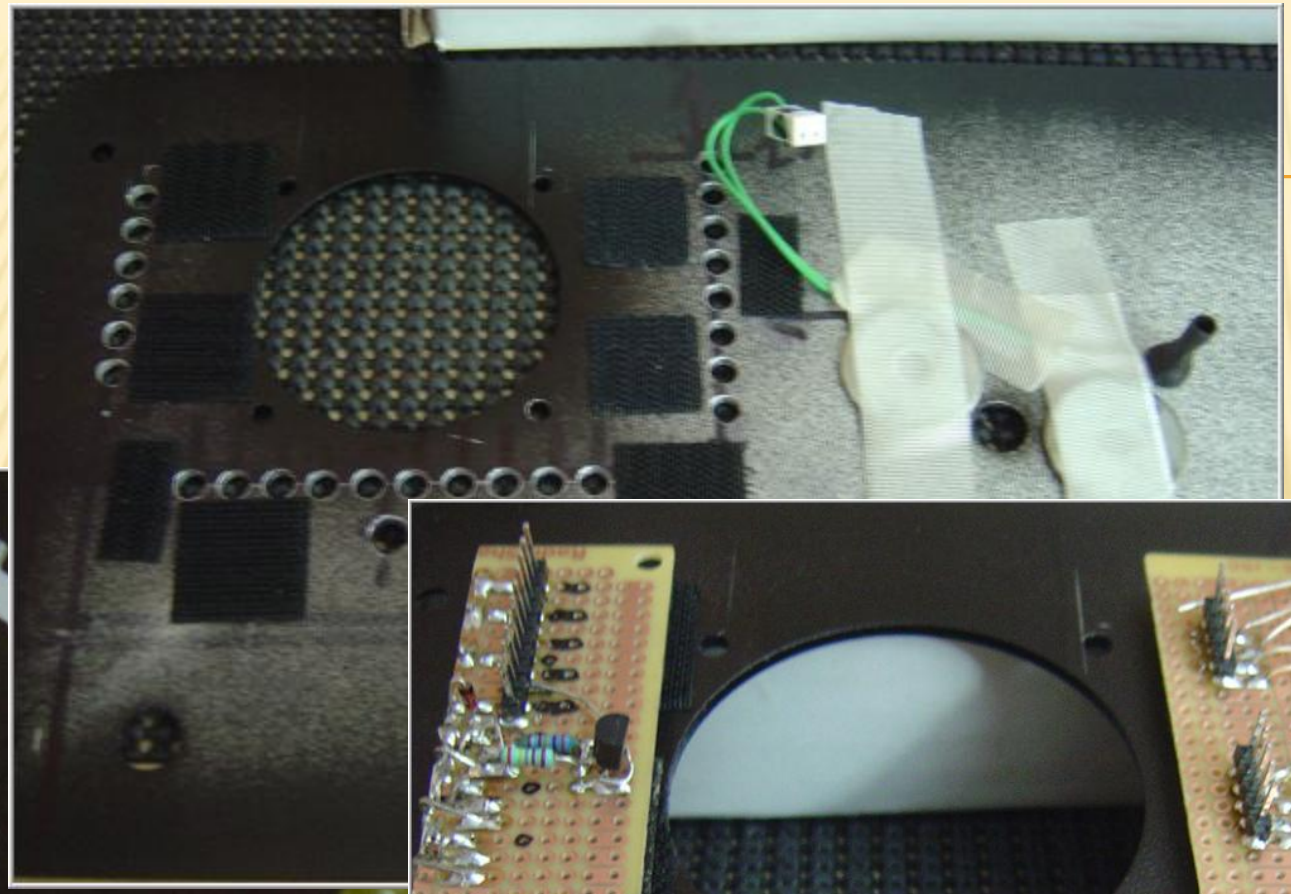


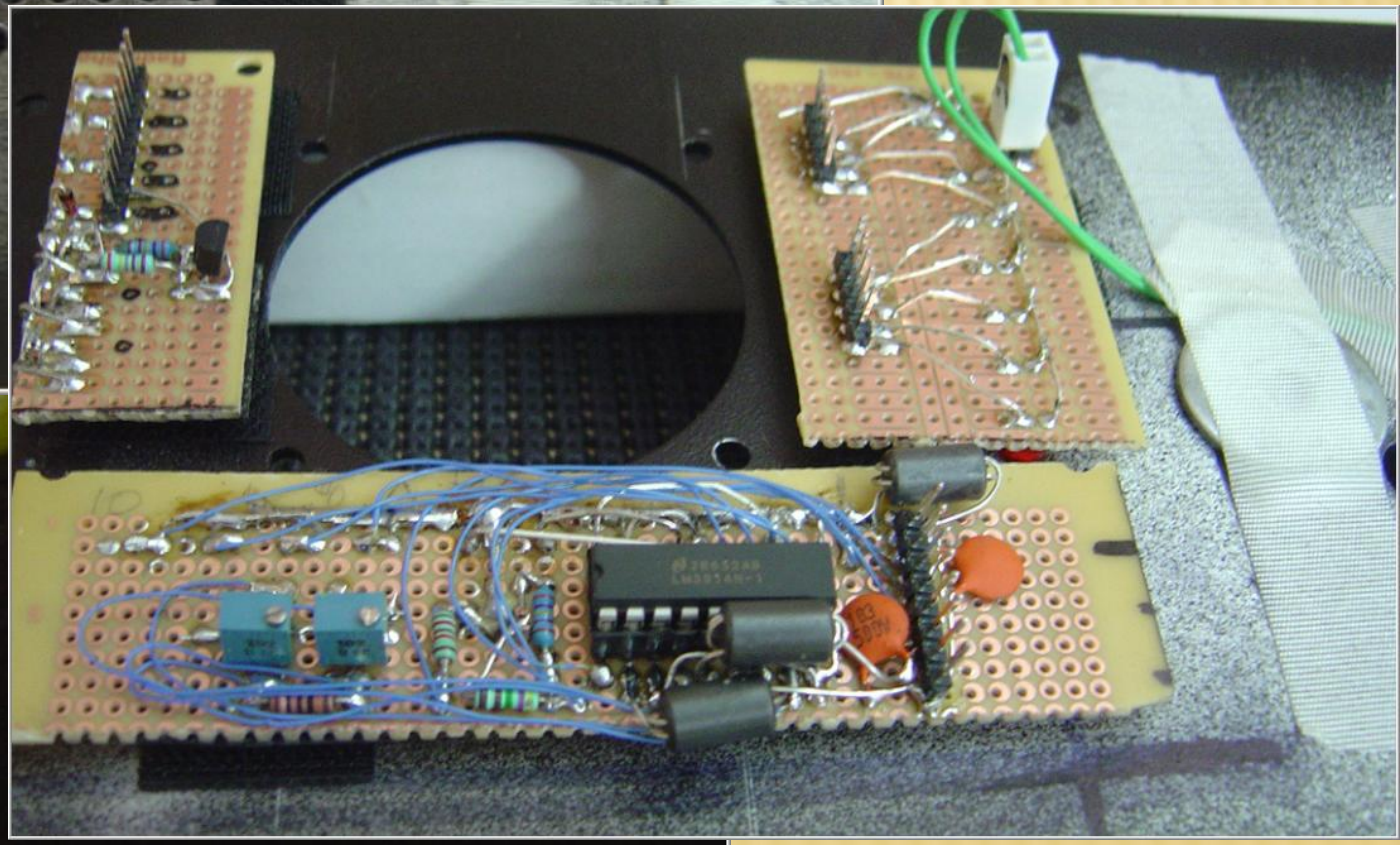
OOPS - METER LEAD SHORTED TO B+ LINE

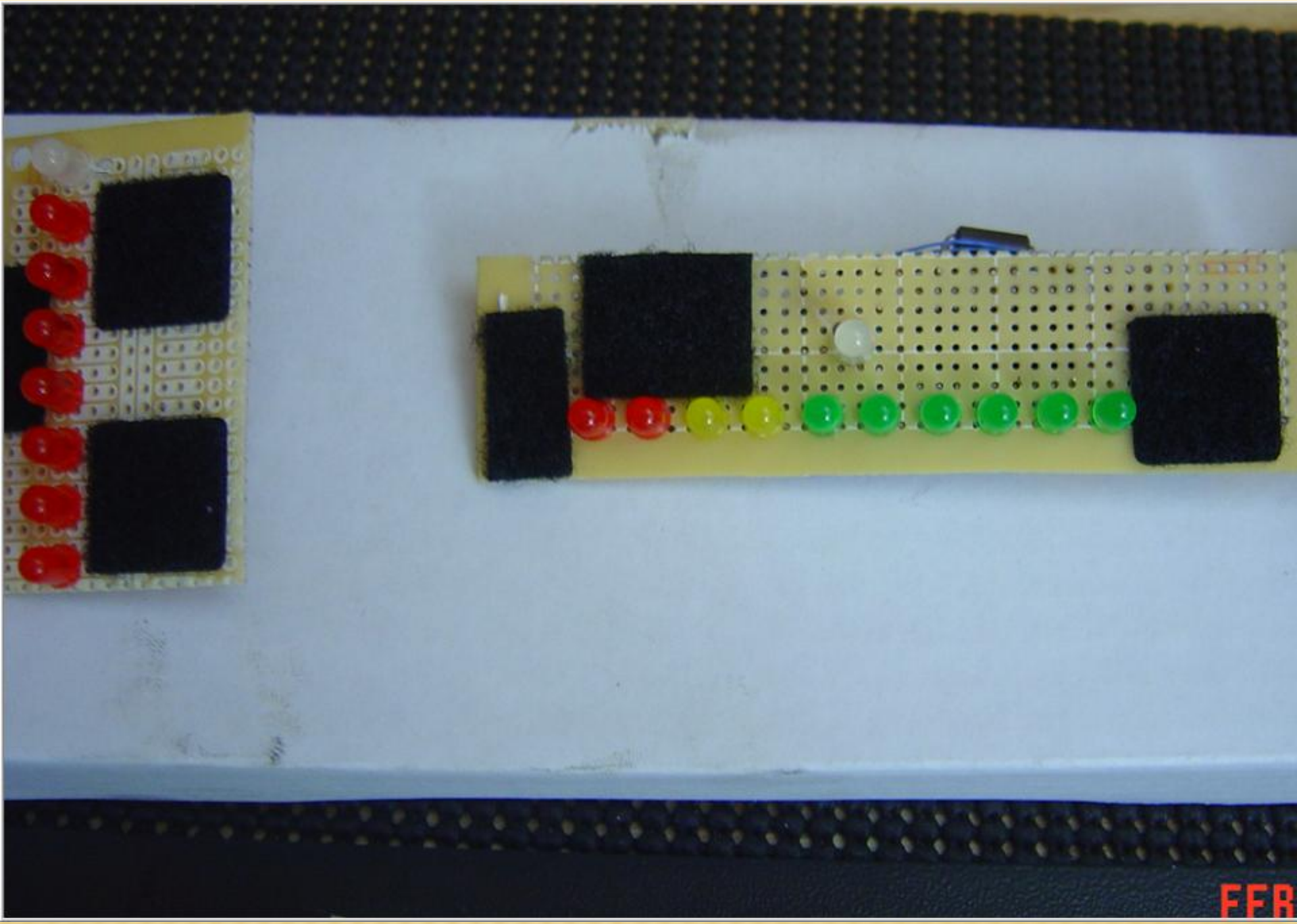


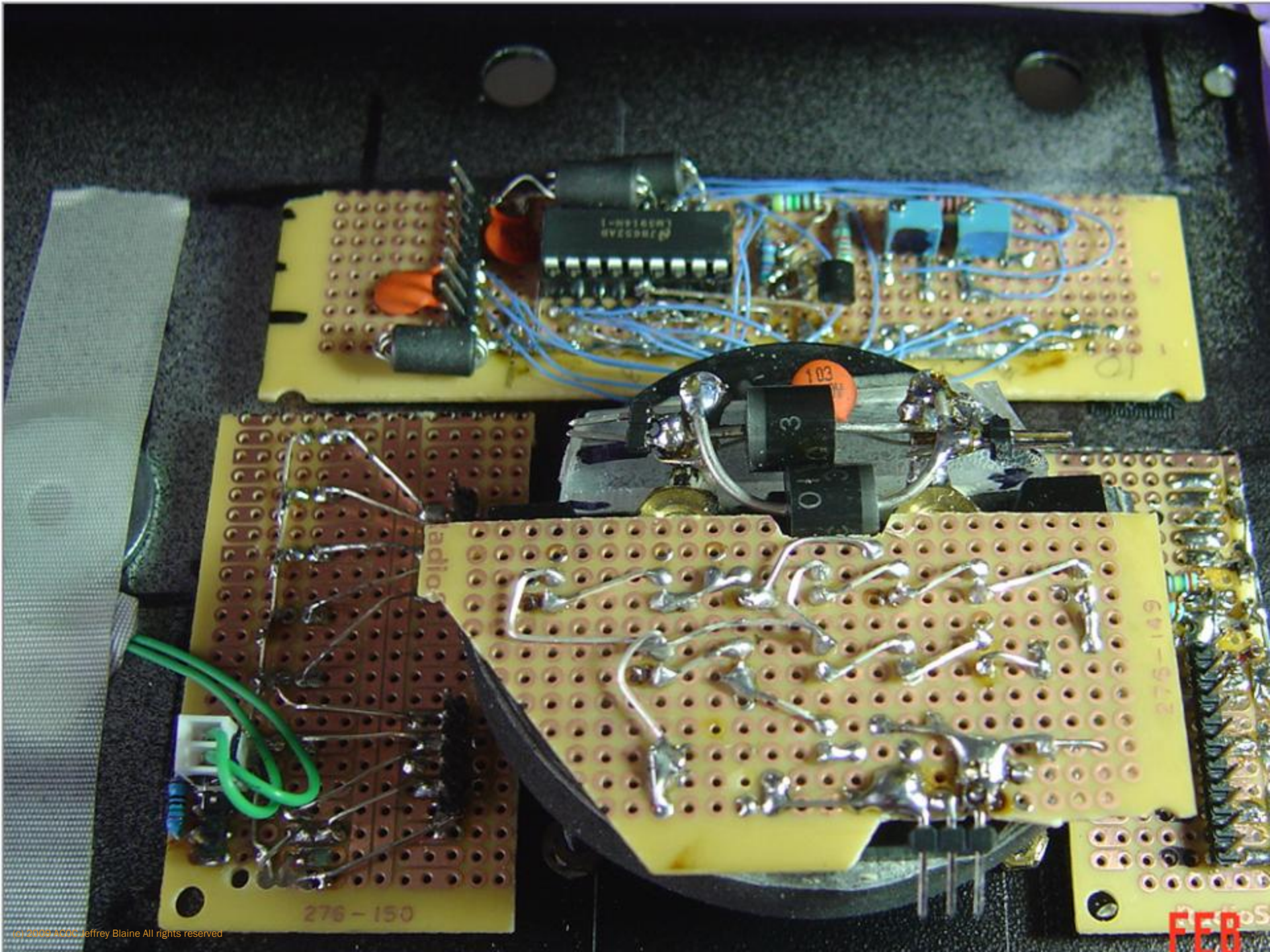




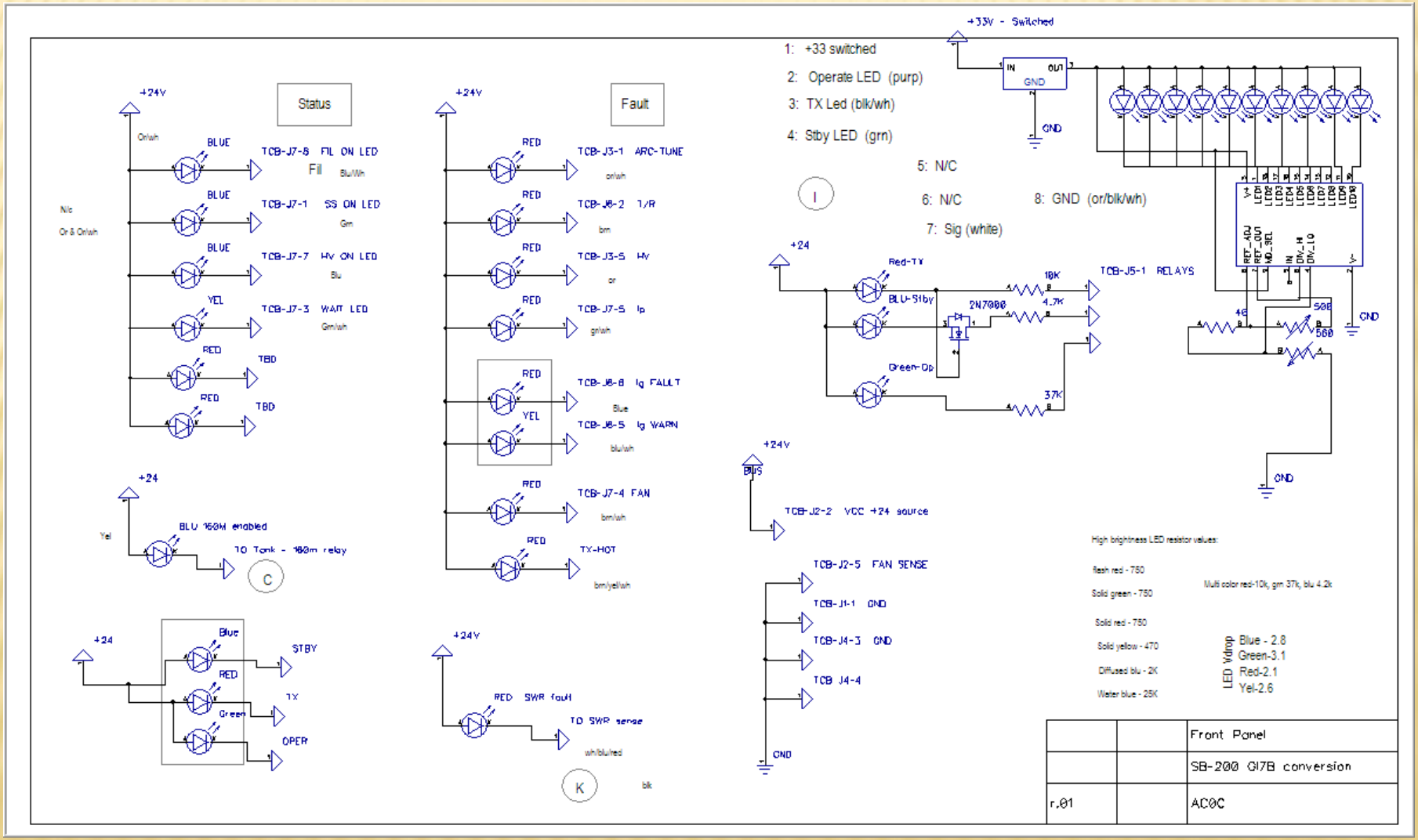




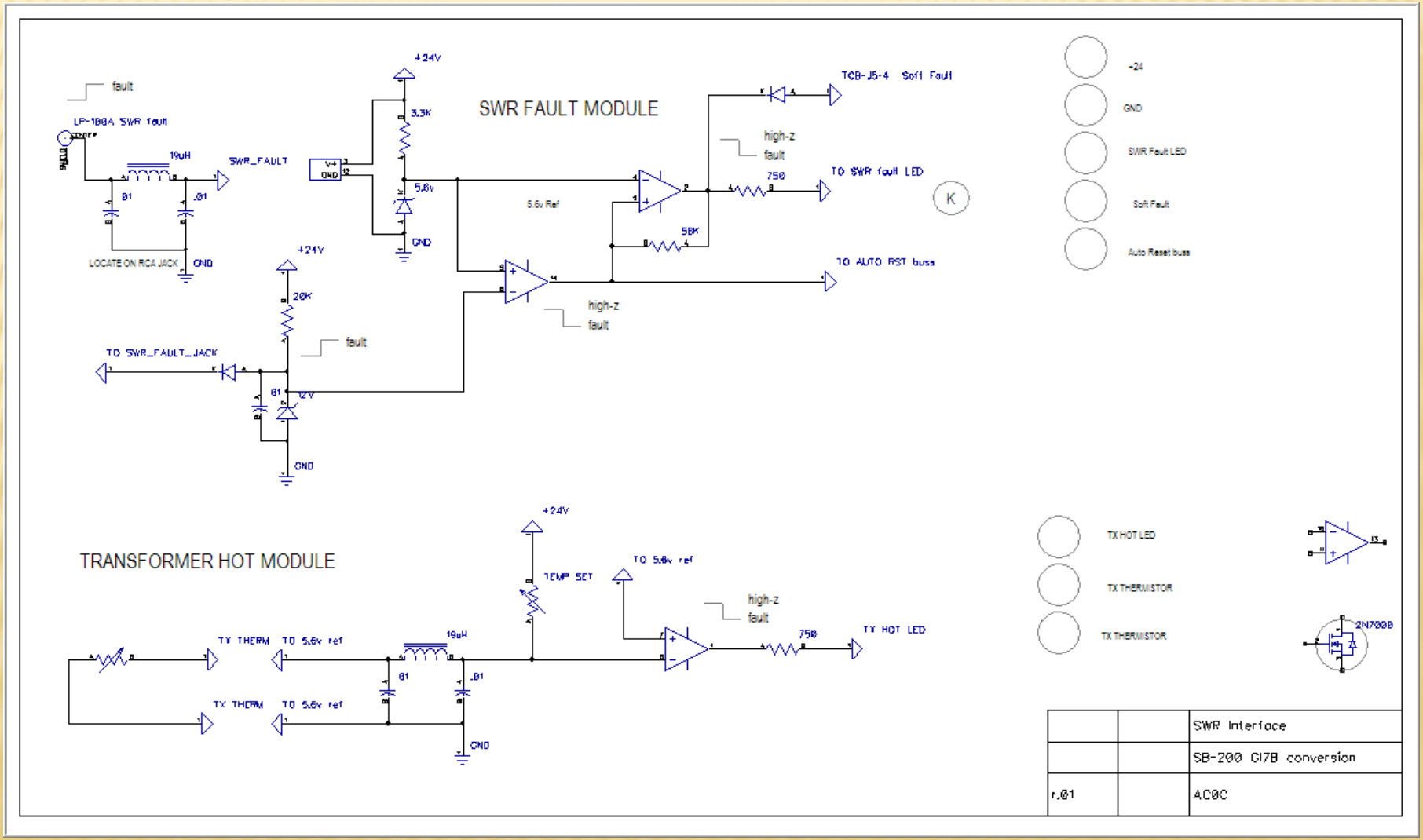




FRONT PANEL STATUS & CONTROL

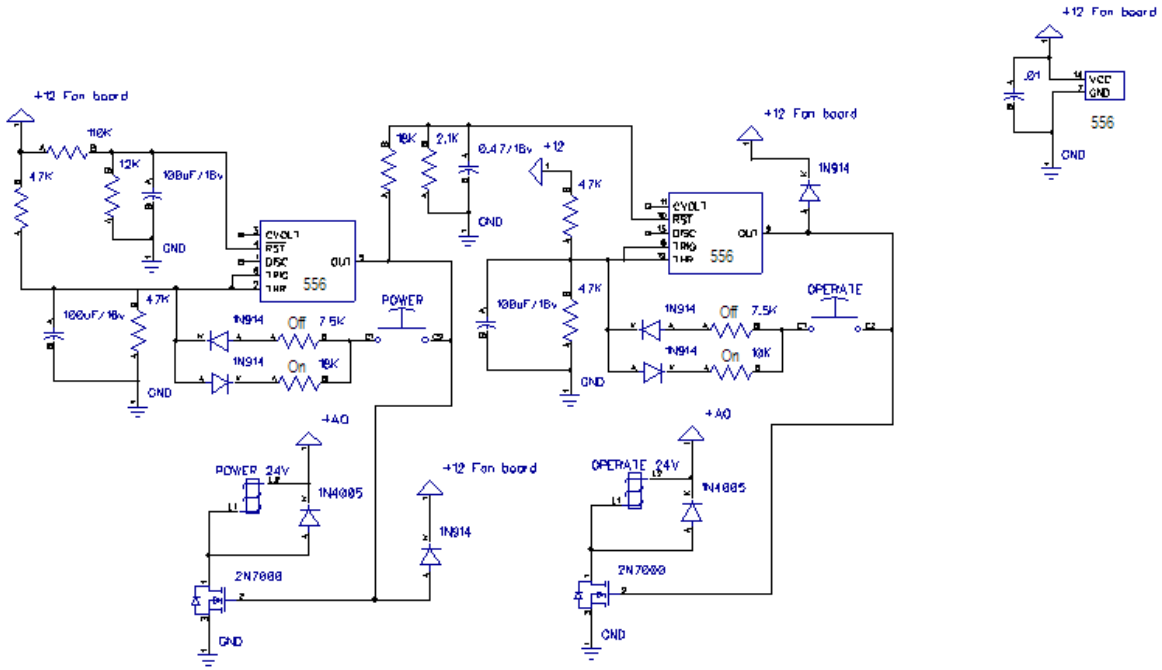


SWR FAULT – TX HOT MODULE



MULTIFUNCTION POWER SWITCH

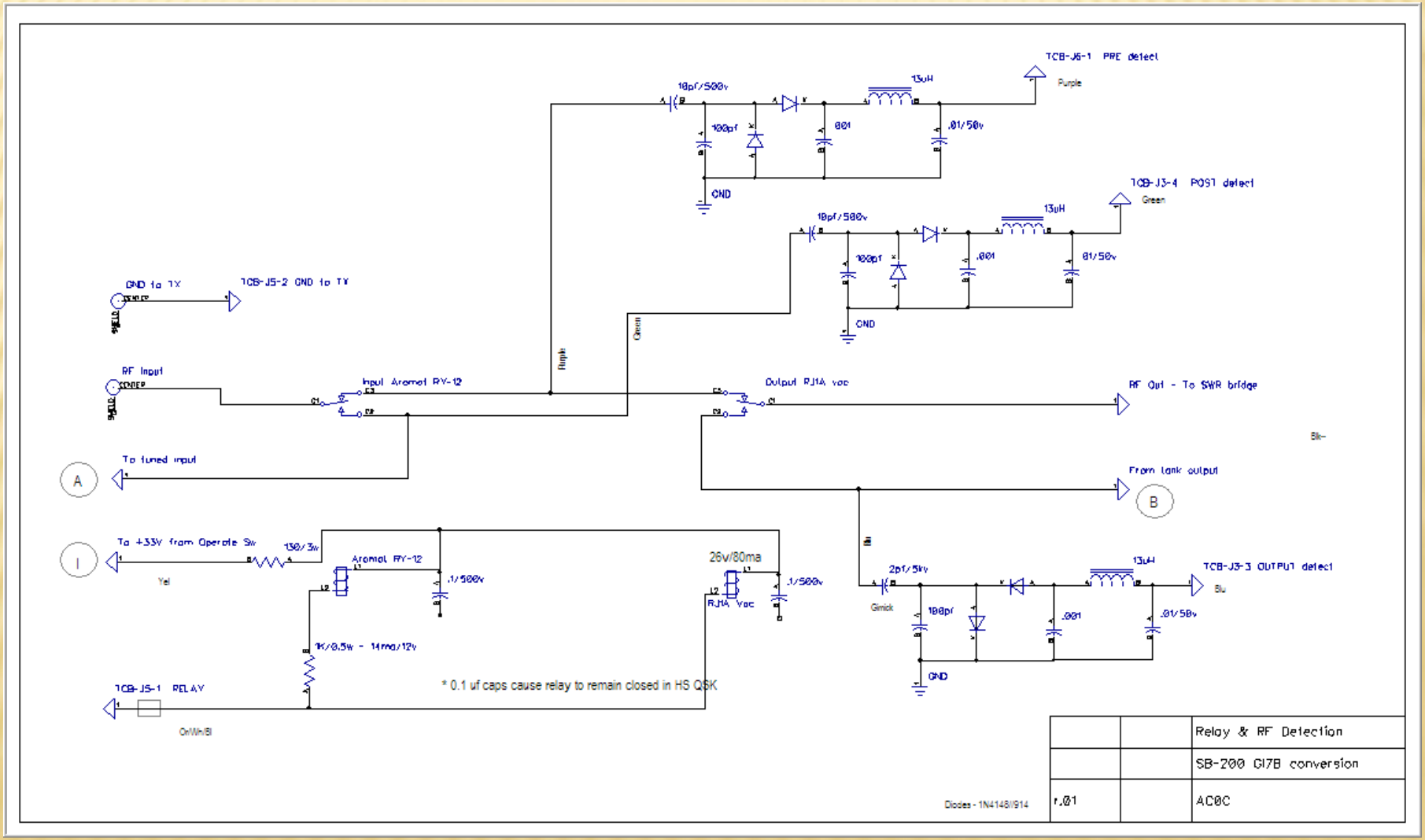
POWER – STANDBY/OP TOGGLE



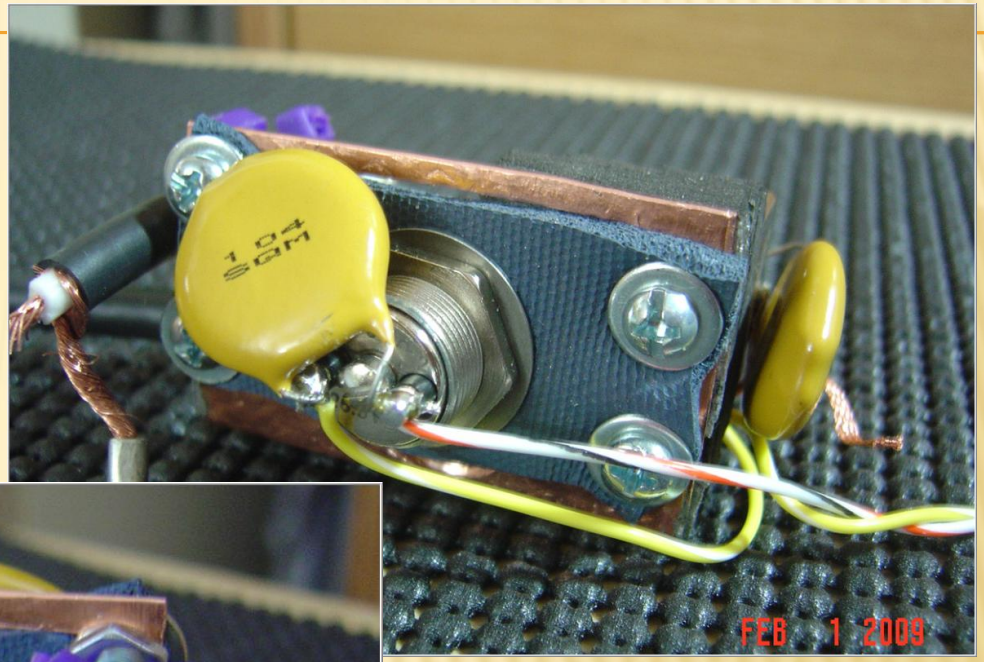
		Power Supply
		SB-200 GI7B conversion
r.01		AC0C

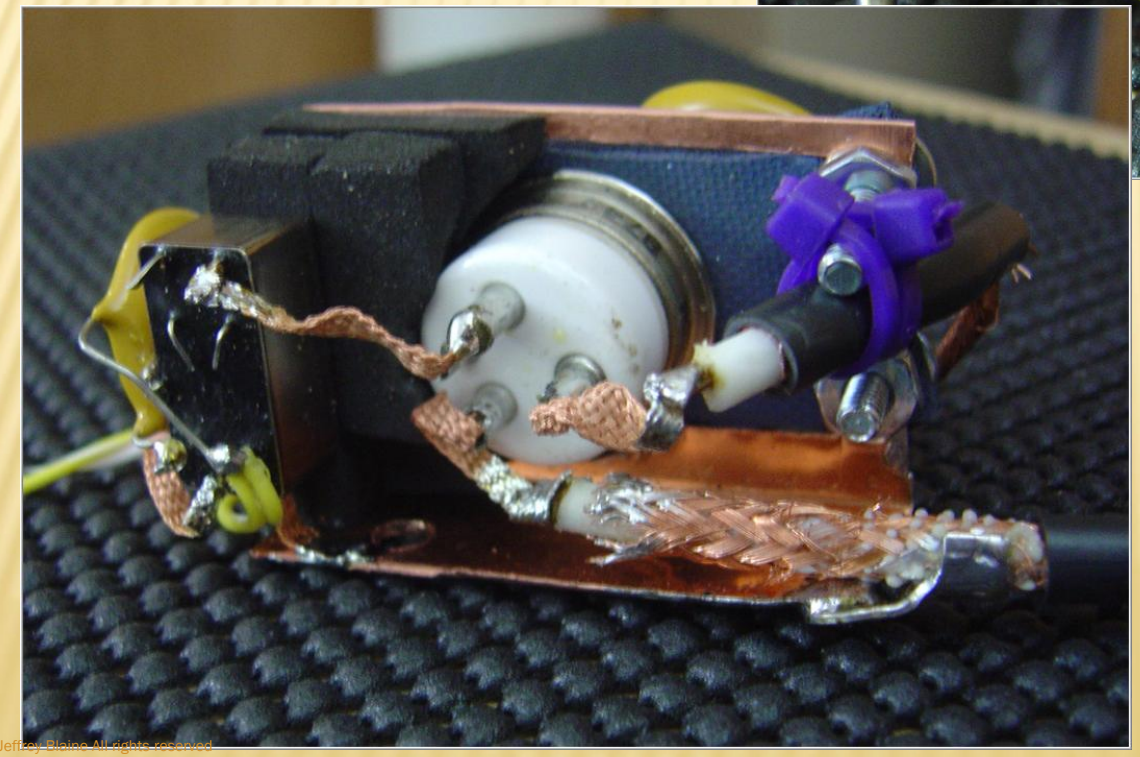
QSK – FAST & QUIET

QSK RELAY AND RF DETECTION



QSK TR SWITCHING





INPUT MATCHING

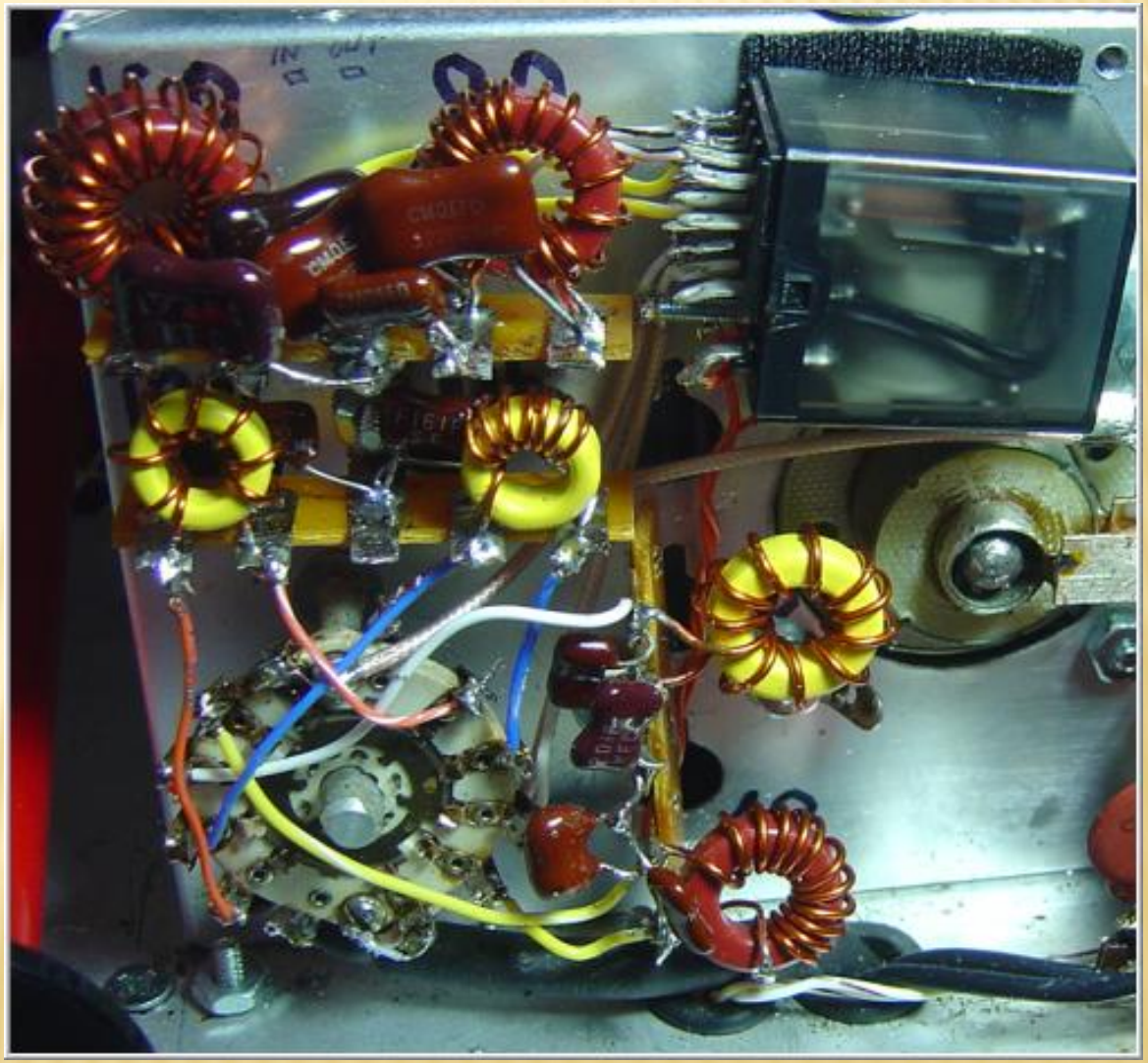
INPUT NETWORKS – NOT EQUAL

Freq	Pdrive	B+	Ip	Pln	POut	Eff	Pd
1.8	58w	2000	505ma	1010w	693w	62.8%	375w
1.9	58w	2000	530ma	1060w	741w	64.4%	377w
2.0	58w	2000	500ma	1000w	695w	63.7%	363w

Freq	Pdrive	B+	Ip	Pln	POut	Eff	Pd
1.8	58w	2000	565ma	1130w	818w	67.3%	370w
1.9	58w	2000	505ma	1018w	765w	69.5%	311w
2.0	58w	2000	500ma	1000w	725w	66.5%	333w

INPUT MATCHING NETWORKS

- PI network on all bands
- 160m/80m networks share the 80m position, band selected by relay
- Toroids don't heat like the OEM air coils did



TRANSFORMERS

TRANSFORMER OPTIONS

- Requirements
  - Approx 1000vac secondary @ 700ma typical plate Ip
  - Doubler configuration means 1.4A CCS secondary
- Harbaugh/Dahl Solution
  - 1000vac @ 0.8a CCS
  - 35C rise
  - More aggressive options discouraged

TRANSFORMER – THE FINAL SOLUTION

- Electronic Product Designs – Peter Eggimann
  - 240v primary, 980 KV secondary
  - 1.4A CCS rated @ 92C rise
  - All components from 200C materials
  - Approx 30 lbs – 4.5” stack (SB200 2.1 stack”)
  - 5 primary taps allow secondary fine-tuning 2300-2560v loaded
  - Imbedded varisistor for direct internal temp measurement
  - Fits fully inside enclosure

NEXT STEPS

ROCK & ROLL...

Conditions:

7.060 mhz
2760v B+
1000ma Ip
100w drive
230ma Ig

Results:

1650w out (net of reflected power)
2760w in
1210w plate dis
56% net efficiency (discounts feed-through power of 100w)

INTERESTING TRENDS

- As the drive level is increased, the efficiency increases

  +5% as drive goes from 30w to 60w

- As the voltage level drops, the efficiency drops:

  -5% as +500v

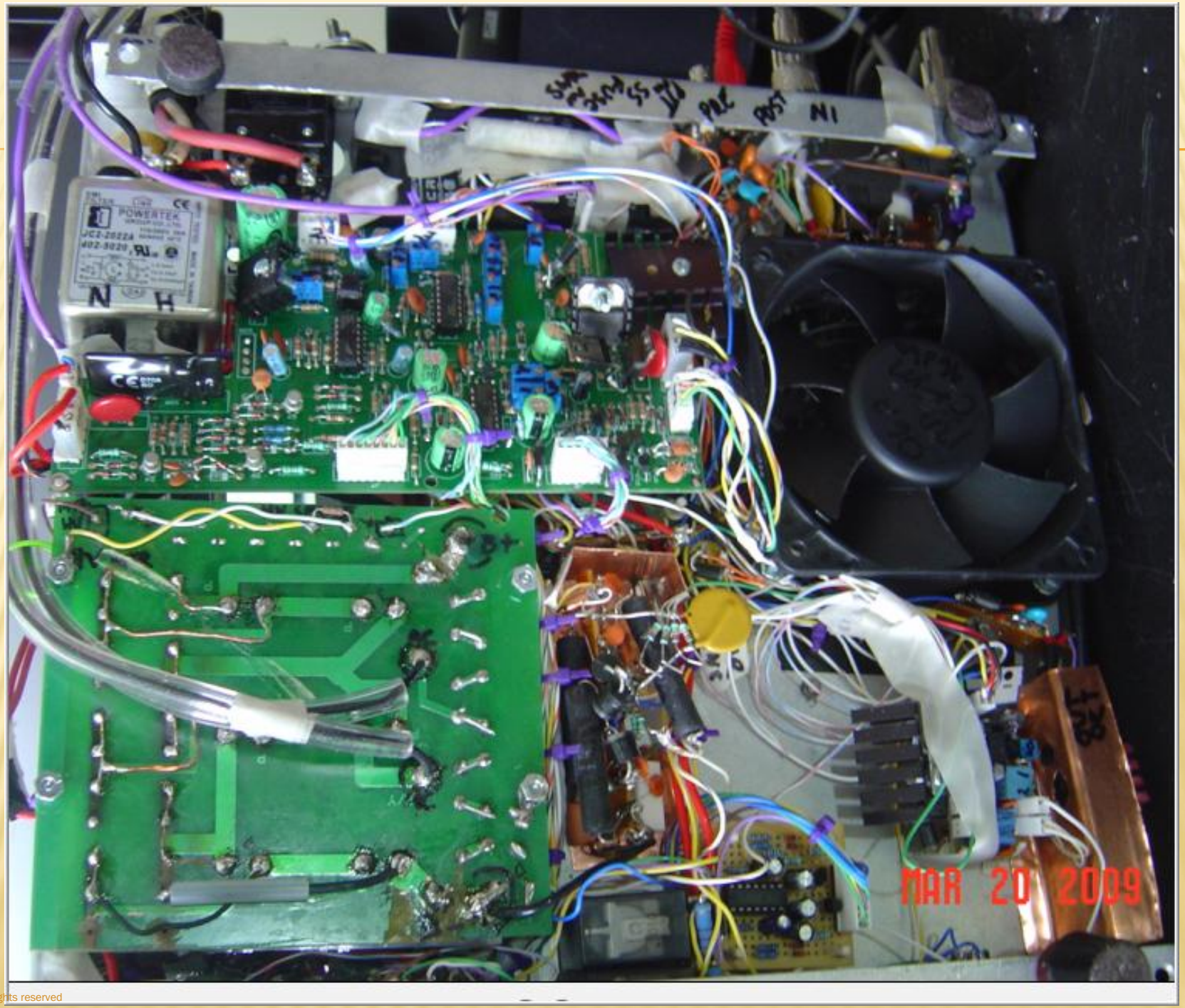
- As voltage level increases, the power output increases:

  +30% as +500v

- As power out increase, the plate dis increases:

  +20% as power output +100%

UNDER-CHASSIS LAYOUT



PENDING

- R&R copper tank
  - Copper for 40m (toroid heating)
  - Dedicated 80m & 160m toroids
  - Optimize values for min plate disipation
- SWR & Tuner interface
- B+ glitch fusing & surge resistors vs. Ip overcurrent
- Wire dress & general housekeeping
- Case metal work
  - Cutouts for improved fan intake (bottom)
  - Cutout heatsink facing RF deck (cap reduction)
  - Custom RF cage cover
  - Final heatsinks

PENDING

- Document cleanup
- QSK switching performance testing
- Power supply PCB cleanup
- Install new transformers

UNANSWERED QUESTIONS

- Operation point vs. plate disipation vs. mode
- Optimal Q
- Optimal bias point

LESSONS LEARNED

- Educational justification of $$ is critical
- You can get killed very damn easy

SPECIAL THANKS TO ELMERS

- W5VIN
- K0RU
- Jack Matlack Metalworking
- WS4Y
- VB7OJ/AB4OJ
- AG6K