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Intro

Sometimes even high-end 8½-digit DMM is not a best tool, since these meters still have limited input resistance and leakage current to earth. Sometimes it's a deal breaker, and small nV-meter with battery power only would be a better use in differential bridge measurements. This is particularly useful for high-voltage high-resistance bridges and such.

For this and few other reasons, we got Fluke Model 845AB null-meter for \$250 USD. Let's see what makes it work.



Electrical Specifications for Model 845

Description	Manufacturer specification
Input Voltage Range	1 microvolt to 1000 volt DC end scale in 19 ranges, using X1 and X3 progression
Input Resistance	100 M Ω on 300 mV range and above, 10 M Ω on 100 mV range and above
Accuracy	$\pm 2\%$ end scale + 0.1 microvolt
Input Isolation	Better than $10^{12} \Omega$
DC CMRR	Better than 160 db
AC CMRR	100 volts RMS or 120 db greater than end scale, whichever is less
AC Normal Mode Rejection (60Hz+)	AC voltages 60 db above end scale will effect reading <2% of end scale
Recorder Output	0-1 volt, one side at chassis ground; to 0.5% of end scale. Output can be operated as a DC amplifier with a \leq gain of 120 db

Stability of Zero	Better than 0.15 microvolt/hour, Better than 0.3 microvolt/day
Temperature Coefficient of Zero	Less than 0.1 microvolt/degree C from 15 °C to 35 °C
Zero Control Range	±5 microvolt minimum
Overload Protection	Up to 1100 volts dc may be applied on any range. Typical recovery time is 4s
Input Power	Rechargeable battery or 115/230 VAC +/- 10%, 50 to 440 Hz
Battery life	40 hours operation on full charge, trickle charge on line power
Weight	10 pounds
Size	8 inches high by 8 inches wide by 9 inches deep

Fluke 845AB were sold new for \$2500 USD during their lifetime and were considered a Primary Standards Laboratory-grade electronic instruments. Fluke 845AR was also used by industry as part of other instrumentation, such as resistance bridge measurement system and DC voltage standards.

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If you willing to contribute or add your experience regarding test instruments repairs or provide extra information, you can do so [following these simple instructions](#)

Manuals

[Fluke 845A 845AB instruction manual \(not complete\), November 1967](#)

[Fluke 845A 845AB some pages from manual](#)

[Another copy of Fluke 845AB manual, complete with high-resolution schematics](#)

[LED modification from KO4BB site](#)

[Fluke 845AR instruction manual \(rackmount version\), April 1968](#)

[Fluke 845AR instruction manual](#)

Credits for Glenn B. from EEVBlog forums for providing copy at 3rd document.

Unit controls and exterior



Meter's front panel is very clean and easy to use. POWER switch have 5 positions:

- OFF – no comment required, everything turned off

- LINE OPR – operation from mains power
- BAT CHG/LINE OPR – operation from mains power and charging of internal battery. Full recharge time is 16 hours.
- BAT CHK – check battery voltage. Meter should deflect needle in “BATTERY O.K.” zone if battery is charged.
- BAT OPR – operation from battery power. Manual states at least 40 hours of continuous lifetime on single charge.

Black OPR rotary knob allow to select measurements from input terminal or from short to common to set zero by related ZERO rotary knob.

Isolated output provides interface to graphing meter or datalogger. Full scale is in range -1.0/1.0V, but it actually can go much higher than that.

Central rotary switch allow selection of input voltage range, from 1 μ V to 1000 V, in total 19 ranges.

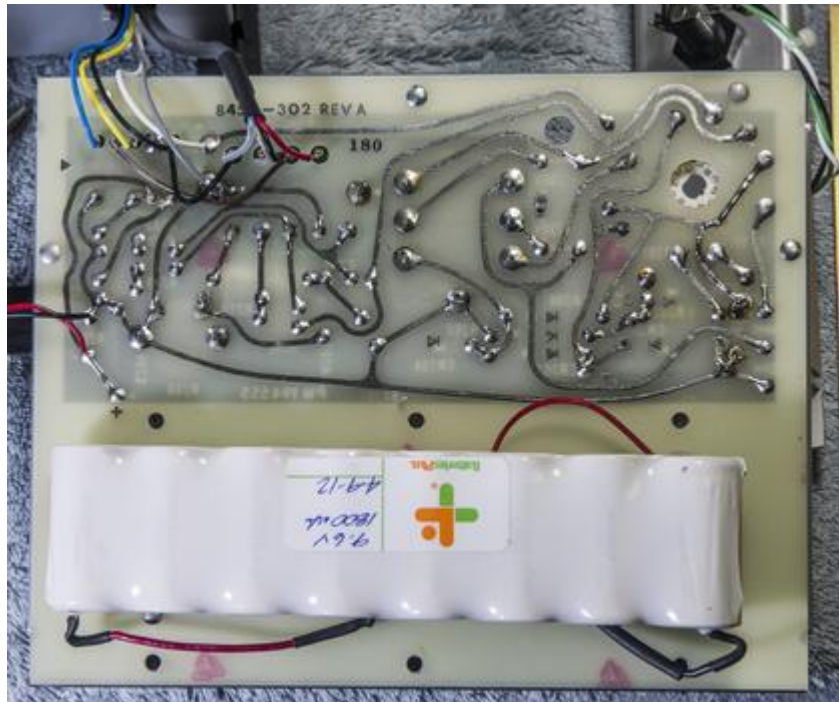
Input terminals are made from non-plated bare copper binding posts. Guard allow guarding to reduce leakage even further, to 10^{13} at best. There is no back-light for meter.



Overall chassis is well built and rather heavy-duty. The only plastic parts are knobs and meter frame. Rear panel have fuse holder and standard C14 IEC mains socket.

Tear-down and construction

Schematics combined from Fluke 845AR instruction manual is provided for your reference.



If one to trust label on battery pack, it's rather fresh and unit was serviced before.

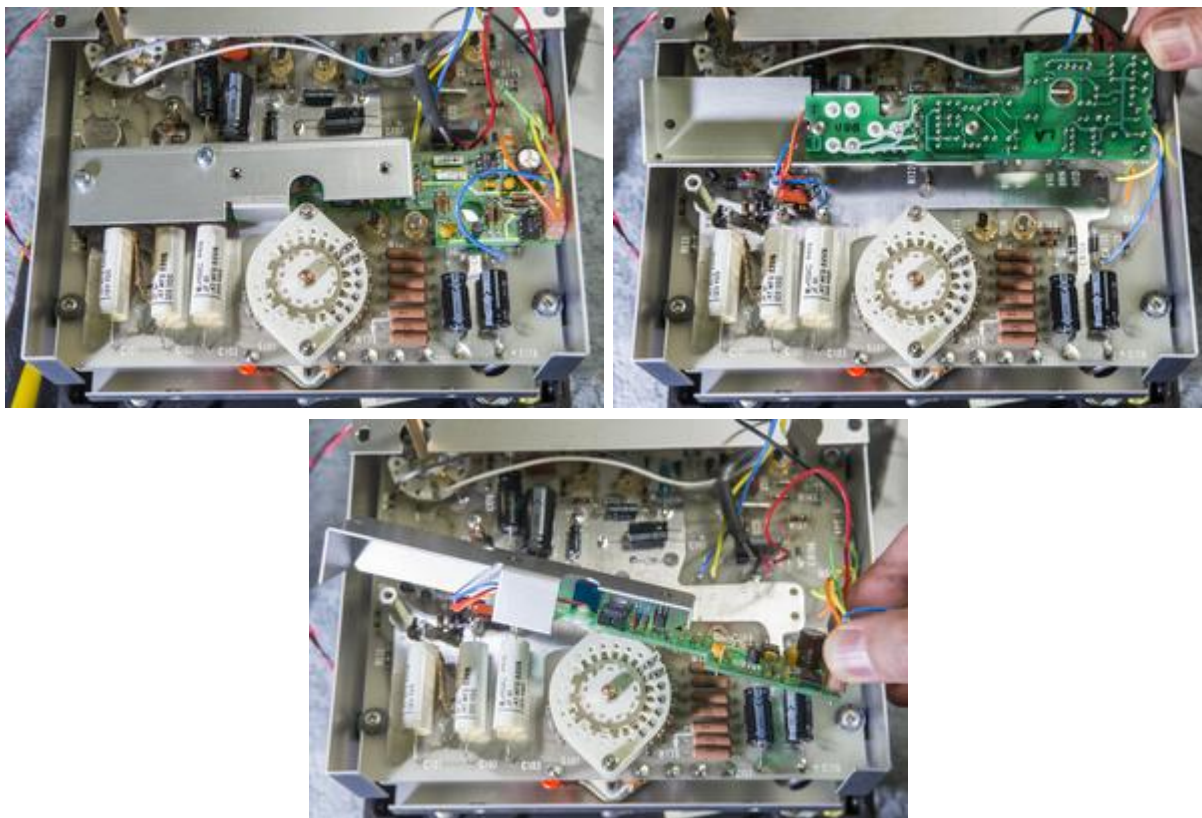
A sticker on battery says:

9.6V
1800mAh
4-9-12

This probably means battery installation time, 4th September 2012. Measured battery voltage at +10.96 VDC, it's OK.

Now, let's remove aluminum covers or guarded section and see what's inside.

Chopper amplifier



I was really expected to see infamous neon tubes, light guides and photo-resistor chopper amplifier, but was greeted instead with alien-looking green PCB with micropower regulator **Linear LT1120CN8** and few HP 2731 optocouplers(?) !

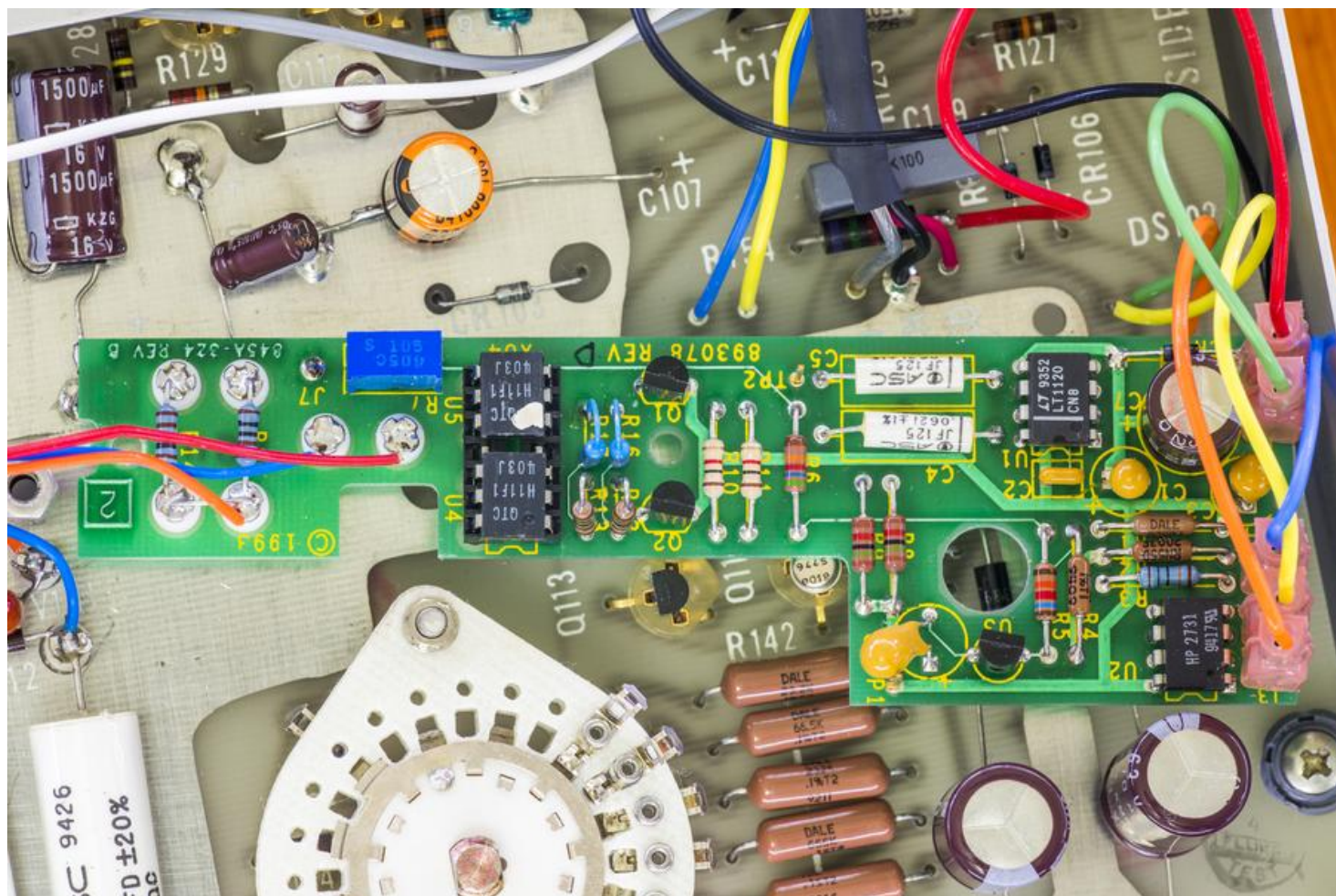
LT1120 dated with 1993 week 52. Is it that optically-isolated Bilateral Analog chopper, which mentioned in Fluke 845AB manual's note in 7/1993 print?

NOTE

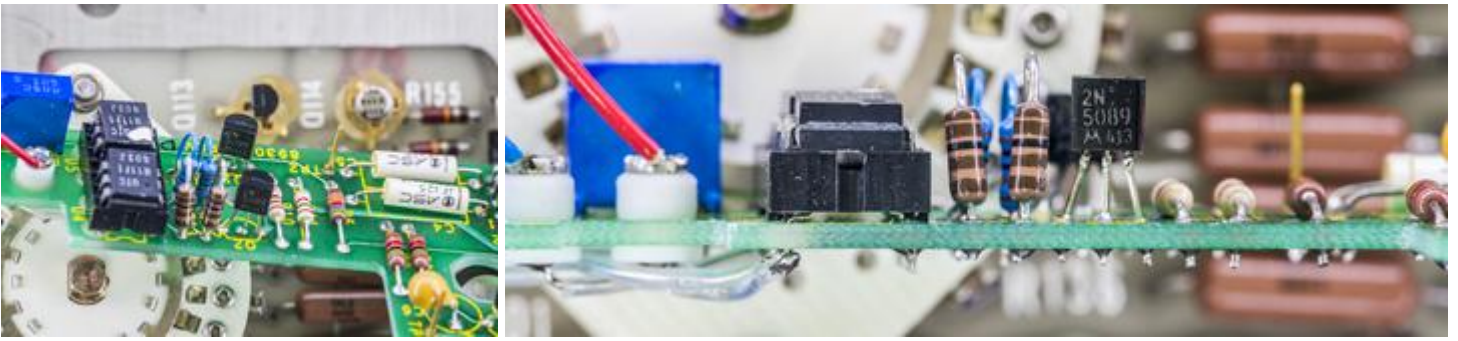
A major circuit modification has been made to the Fluke Model 845AB. This change entails the complete redesign of the Photo Modulator, previously based on photo-conductive resistors. The new circuit now employs optically-isolated Bilateral Analog FETs, and is fabricated on an additional circuit board.

Updates to the relevant sections of this manual are now in process and will be available for shipment approximately December 1993. This manual is completely accurate with regard to specifications and operating instructions. The circuit modifications are totally internal and are completely transparent to the user.

Indeed it is. I'll be reverse engineering this circuit later on so we can know exactly what we're dealing with here, and evaluate possibility of future improvements.

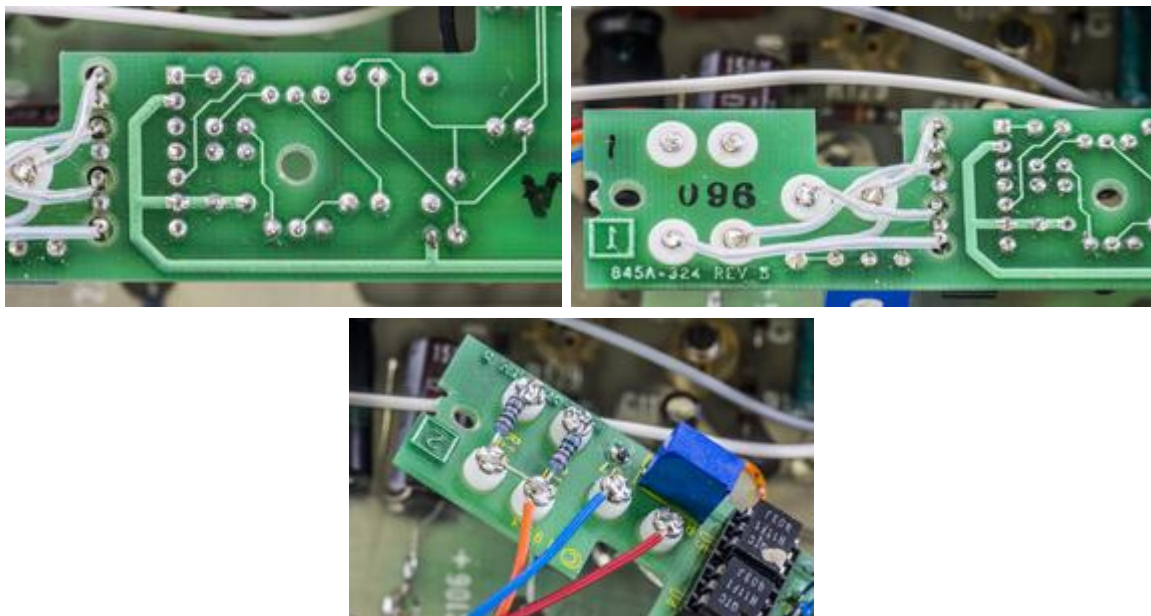


Here are some additional photos of chopper module board:

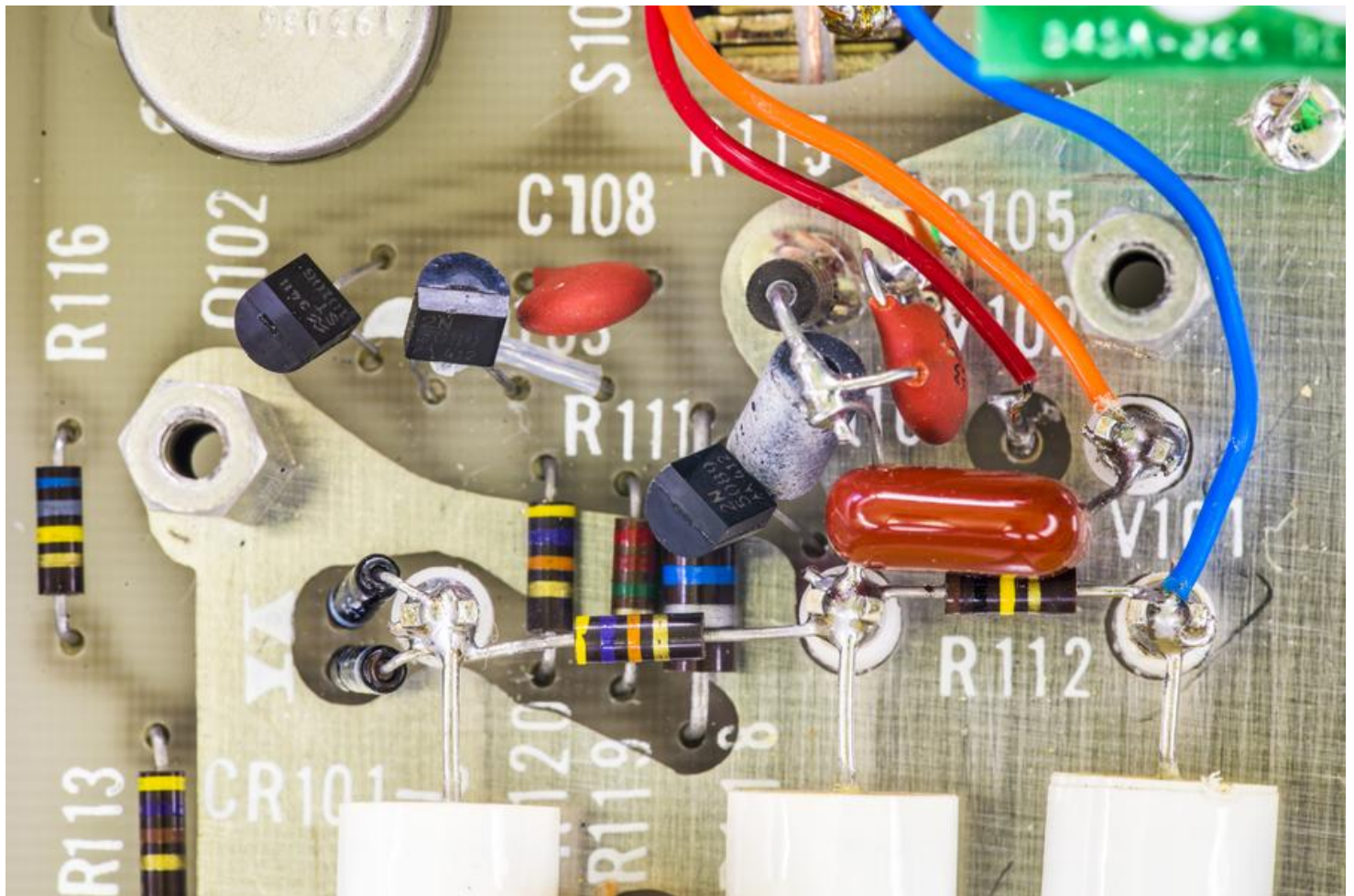


Transistors used are general purpose NPN's **2N5089** in T092 package with h_{FE} about 400 and 30V maximum voltage.

Optocouplers are **Fairchild H11F1**, which are good FET switches with decent linearity and low offsets.



And connection of three wires from high impedance nodes on base board:



Repair

After initial inspection and testing next issues were spotted:

- Meter does not read anything in BAT OPR mode. It's just dead on zero, like no power is supplied, even though BAT CHK shows good battery
- In LINE OPR mode meter is unable to zero on ranges below 30 μ V

Rest of ranges seems to be working as expected. Input resistance measured by 3458A is 100 M Ω on high voltage ranges, 10 M Ω on mV ranges and ~250K Ω on ranges below 1 mV.

Main supply voltage rails +15 and -15 were measured at 17.65 and -17.8 VDC respectively.



No operation in BAT OPR mode

First issue was resolved by fixing blown PCB track on Power supply P/C assembly, connecting battery positive terminal to S201C switch. This repair covered in YouTube video below.

Meter cannot zero on lowest ranges

Green PCB with chopper assembly has blue multi-turn trimmer pot, accessible from the side. This trimmer adjustment allowed shifting zero, and now meter can be zeroed on lowest 1 μV range.

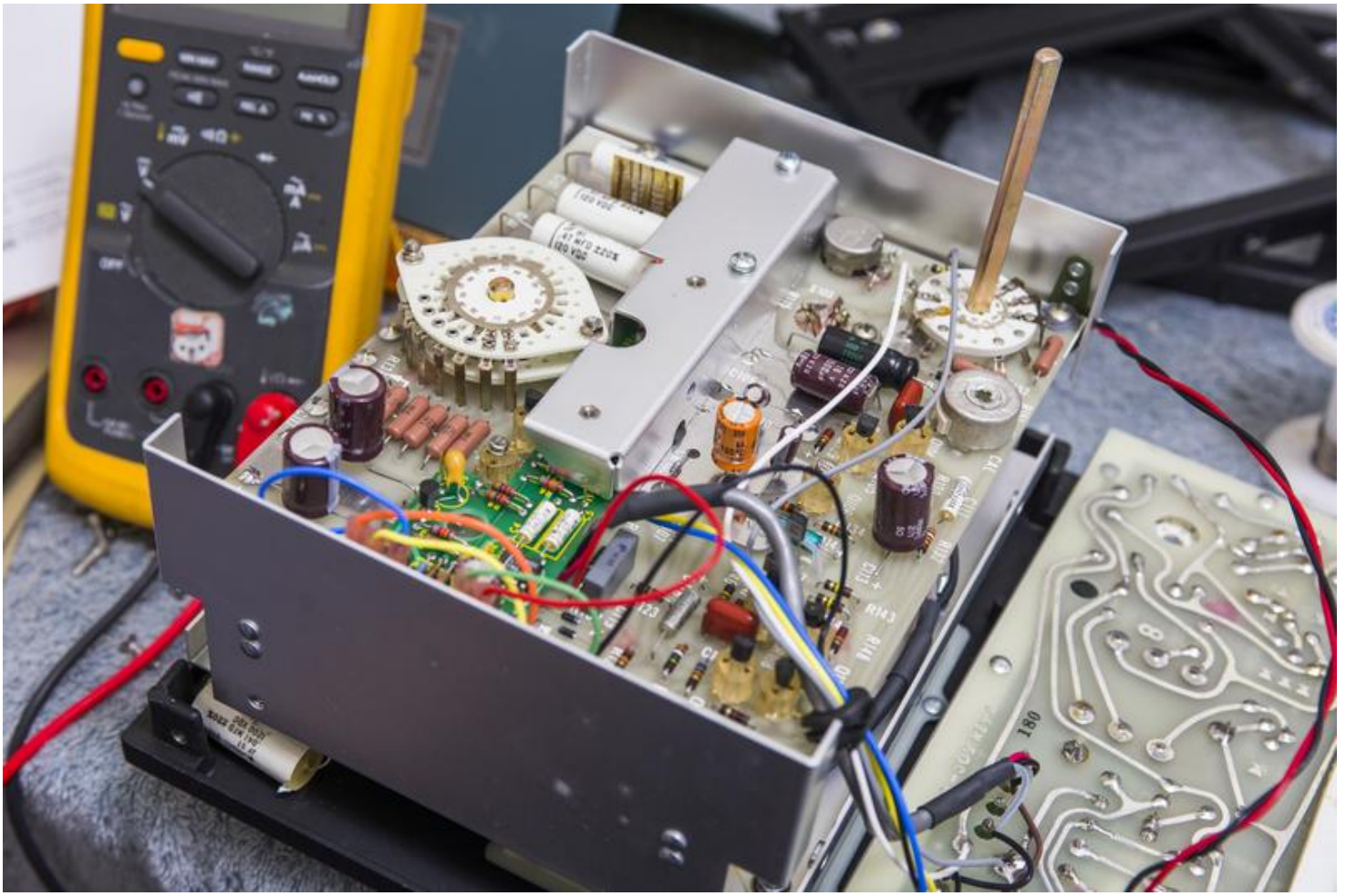
This was an easy repair.

Replacement of all electrolytic caps

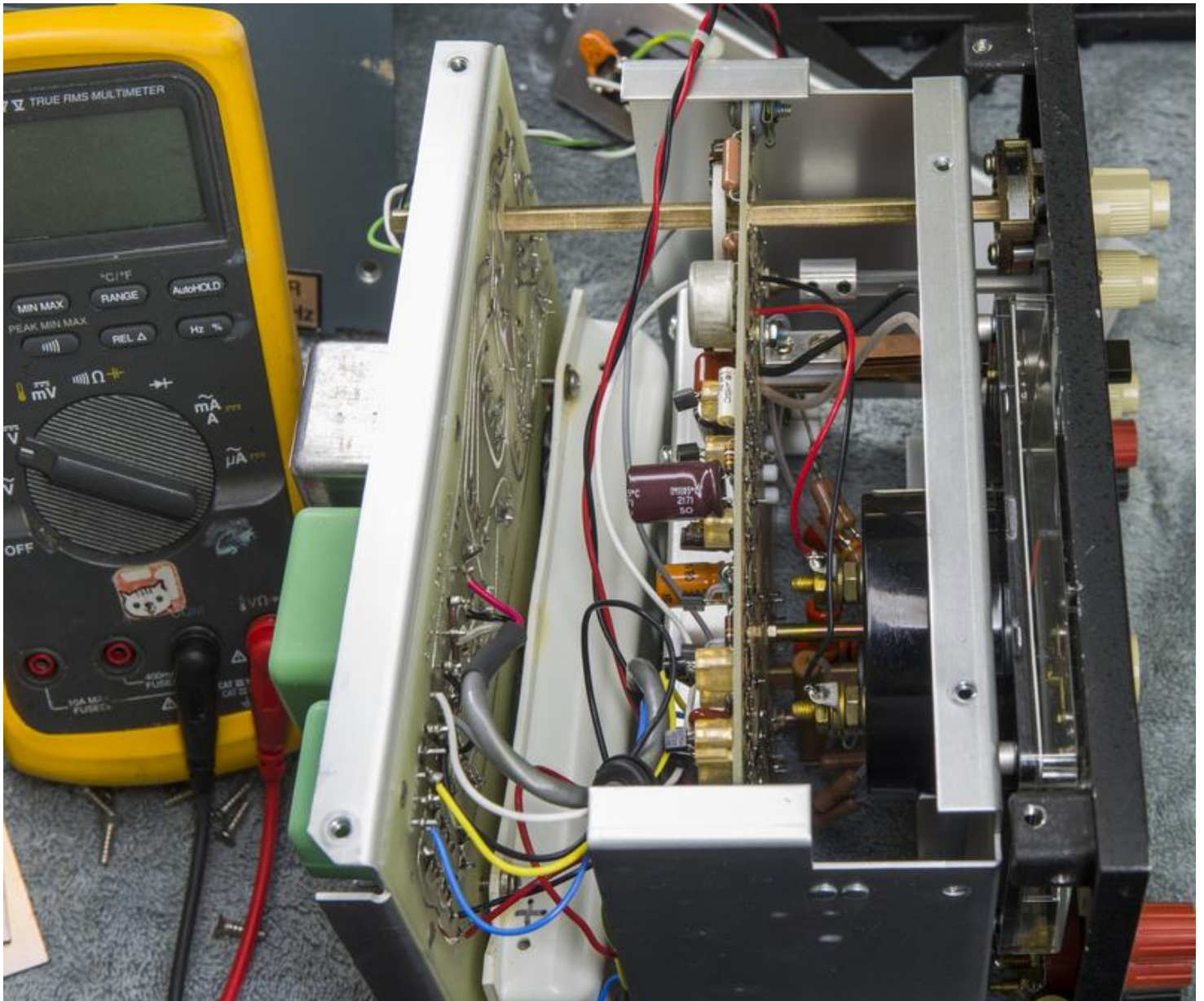
As usual with equipment with age over 10, replacement of all electrolytic capacitors should be a must-have maintenance procedure. This saves trouble of cleaning electrolyte leaks and further destruction. If you think that's rare malfunction, be sure to check [our Keithley Model 2001](#) experience with no less than 7 meters affected by damage from old capacitors.



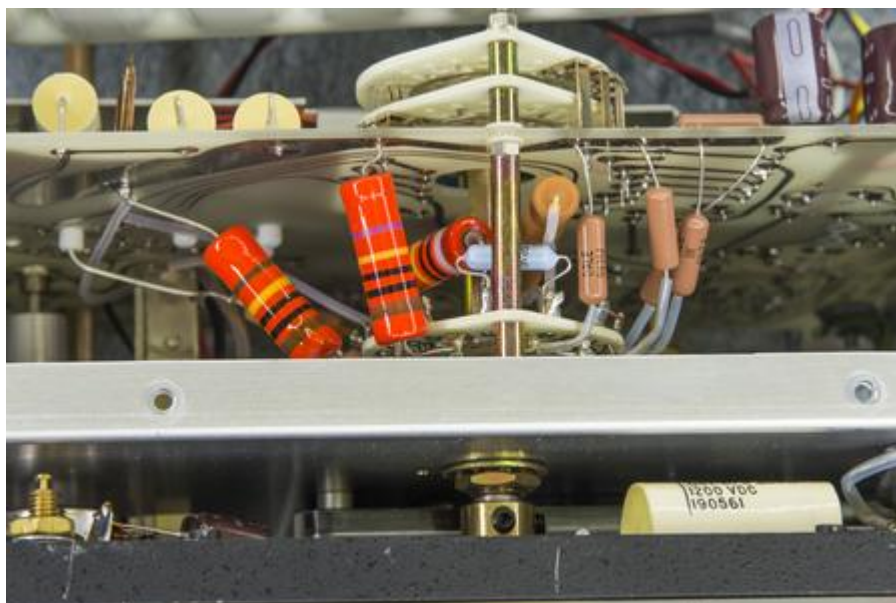
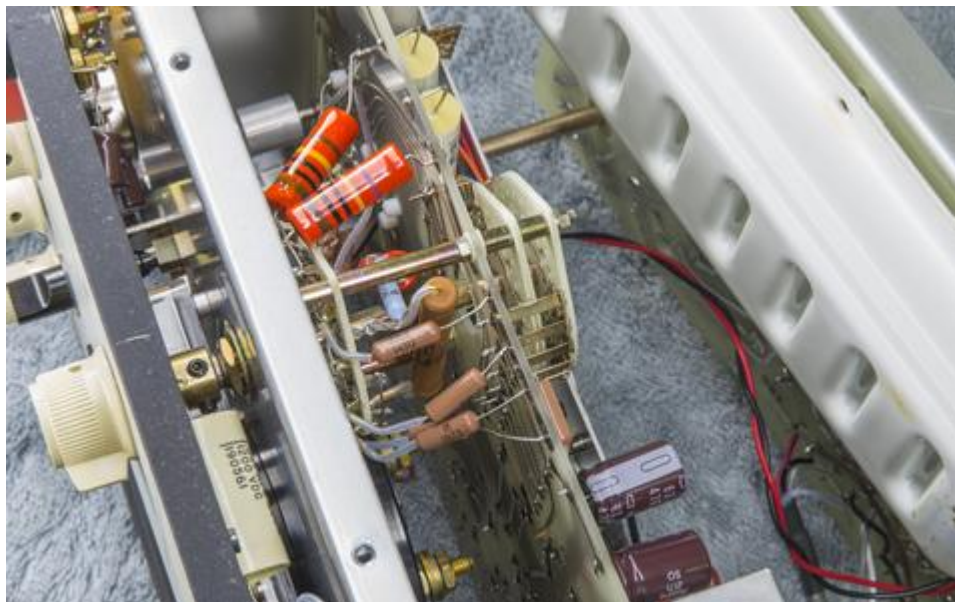
There is plenty space inside, so usual good quality Chemi-Con radial capacitors were used instead of original axial type. I used 470 μ F 63V instead of original 470 μ F 25V and 6.3V caps.



Everything inside is very clean, not a single mark of dust, as there is no vent holes or fan in this device.



Some decent resistors are installed directly on range switch, including large high voltage 90 M Ω monster with golden leads. Most critical wiring protected by Teflon insulation and soldered to Teflon PCB standoffs.



Calibration procedure

Manual section 4-20 have simple calibration procedure. Model 845 should be calibrated once every year. It is recommended that if component replacement is performed, the Model 845 should be re-calibrated. Test and alignment points are illustrated in instruction manual.

Only single +10.000 VDC reference source is required for calibration.

1. - Connect stable DC reference voltage source to Model 845 input. Positive source terminal connected to INPUT, negative source terminal connected to COMMON + GUARD.
2. - Set Model 845 controls to POWER = ON, OPR/ZERO = OPR, RANGE = 10 VOLTS
3. - Enable +10.000 VDC output on a DC reference voltage source.

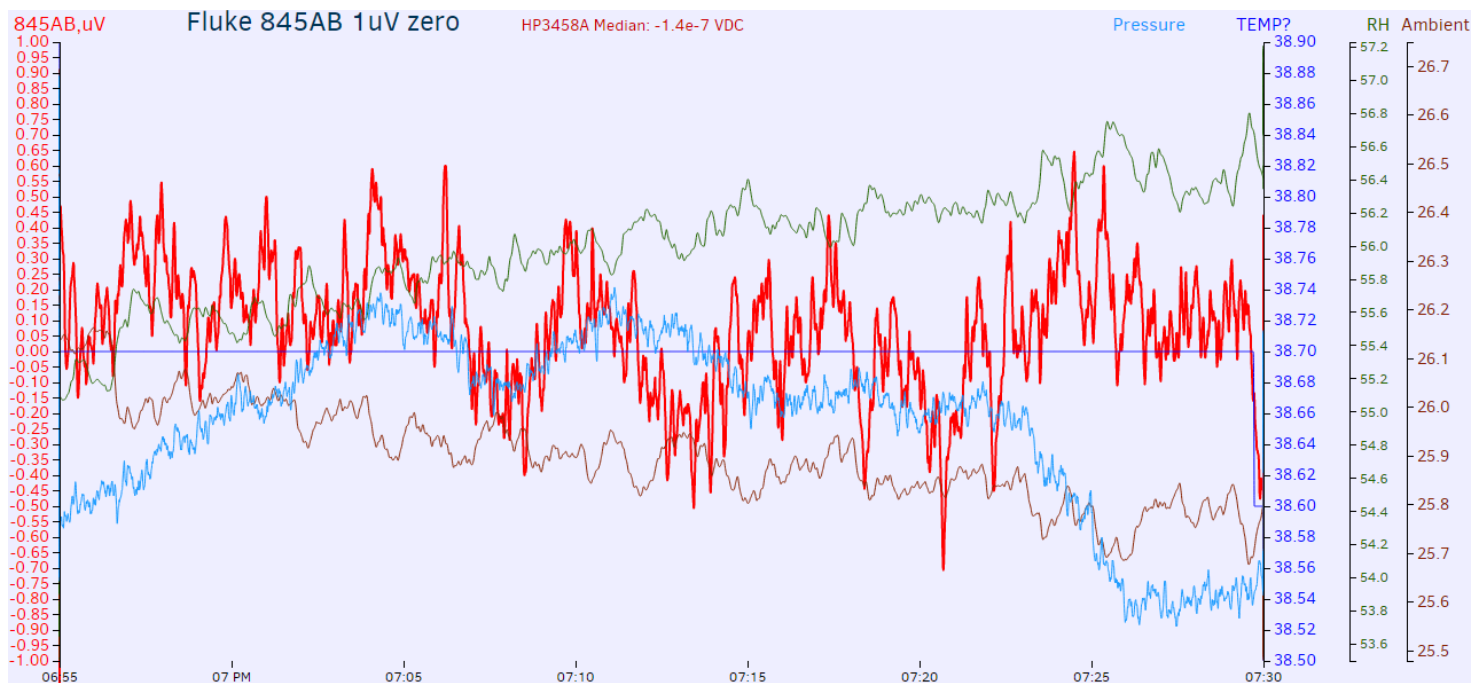
4. - Adjust **R151** for full-scale deflection (+10) on the Model 845 meter

There is also chopper frequency 84 Hz adjustment procedure

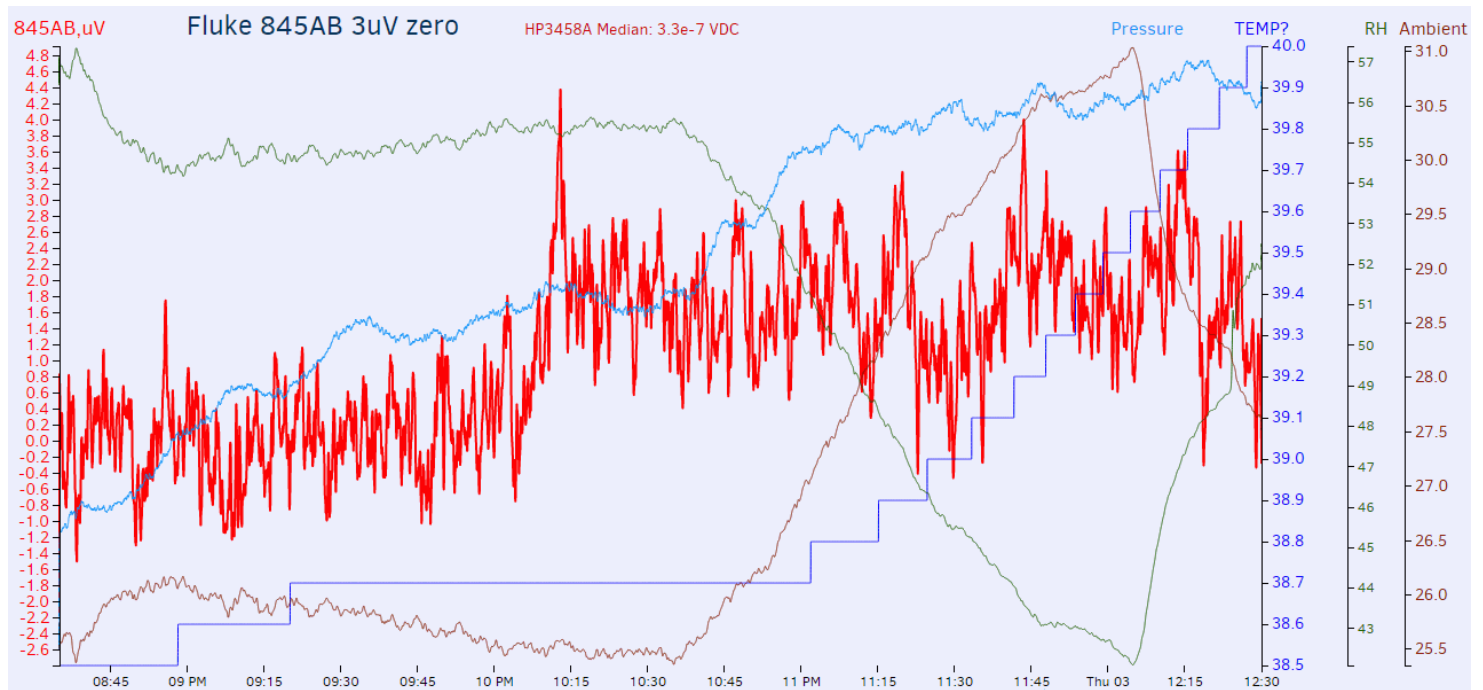
1. - Set Model 845 controls to POWER = ON
2. - Connect oscilloscope or frequency counter between test point **TP10** and ground
3. - Adjust **R206** until the oscilloscope waveform has a time period of 12 milliseconds, or 84 Hz.

Performance test

Here are some graph logs with HP 3458A sampling Fluke 845AB isolated output.



Settings: Fluke 845AB Range: **1 μ V**, OPR switch = ZERO, 3458A DCV auto, 10 NPLC, AZERO ON



Settings: Fluke 845AB Range: **3 μV** , OPR switch = ZERO, 3458A DCV auto, 10 NPLC, AZERO ON

Leakage resistance test

Test leakage of Model 845 will require +10V reference source.

1. - Connect positive source output to Model 845 INPUT, and negative source output to Model 845 EARTH terminal.
2. - Set Model 845 controls to POWER = ON, OPR/ZERO = OPR, RANGE = 300 μV
3. - Model 845 meter should indicate not more than 100 μV , which correspond to leakage resistance $10^{12} \Omega$. Allow sufficient time for meter to stabilize.

Tweaks and modifications

In this section we will discuss possible improvements to this null-meter.

To be done, stay tuned...

Conclusion

Unit was repaired and working well, and became a nice addition to our lab. Feel free to ask any questions in comments!

Author: Illya Tsemenko

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Modified: Nov. 22, 2018, 10:01 a.m.

References

1. [Fluke seminar of using 8508A for null-meter replacement](#)
2. [EEVBlog : Thread discussion about this unit](#)
3. [K04BB's Fluke 845A directory](#)
- 4.