AVO CT 160 Modifications

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The modifications described here were made on a CT160 with serial number ACW330LB.
I had purchased this unit about a year ago from a gentleman in Eindhoven/Netherlands. Except for the original power cord socket which had been replaced by a standard IEC type and a poorly repainted case the cosmetic appearance looked acceptable. Back at home a closer inspection revealed:

- Partially burnt Grid voltage potentiometer RV2. The pot still worked but the coil body was deformed by the heat and did not look very trustworthy.
- Worn out Anode current backing off potentiometer RV4. Even after disassembling, cleaning and lubricating all the wipers and contact areas with contact grease contacting remained unreliable.
- RL1 winding on protective relay and light bulb LP2 open.

I decided to repair these defects, to replace the EB91 with silicon diodes and to partially rework the original circuit.

Basic Circuit and Modifications

I relied much on the circuit diagram drawn by Martin Forsberg, his elaborate explanations in the forum (http://www.vintage-radio.net/forum/showthread.php?t=58088) and other private information from him.

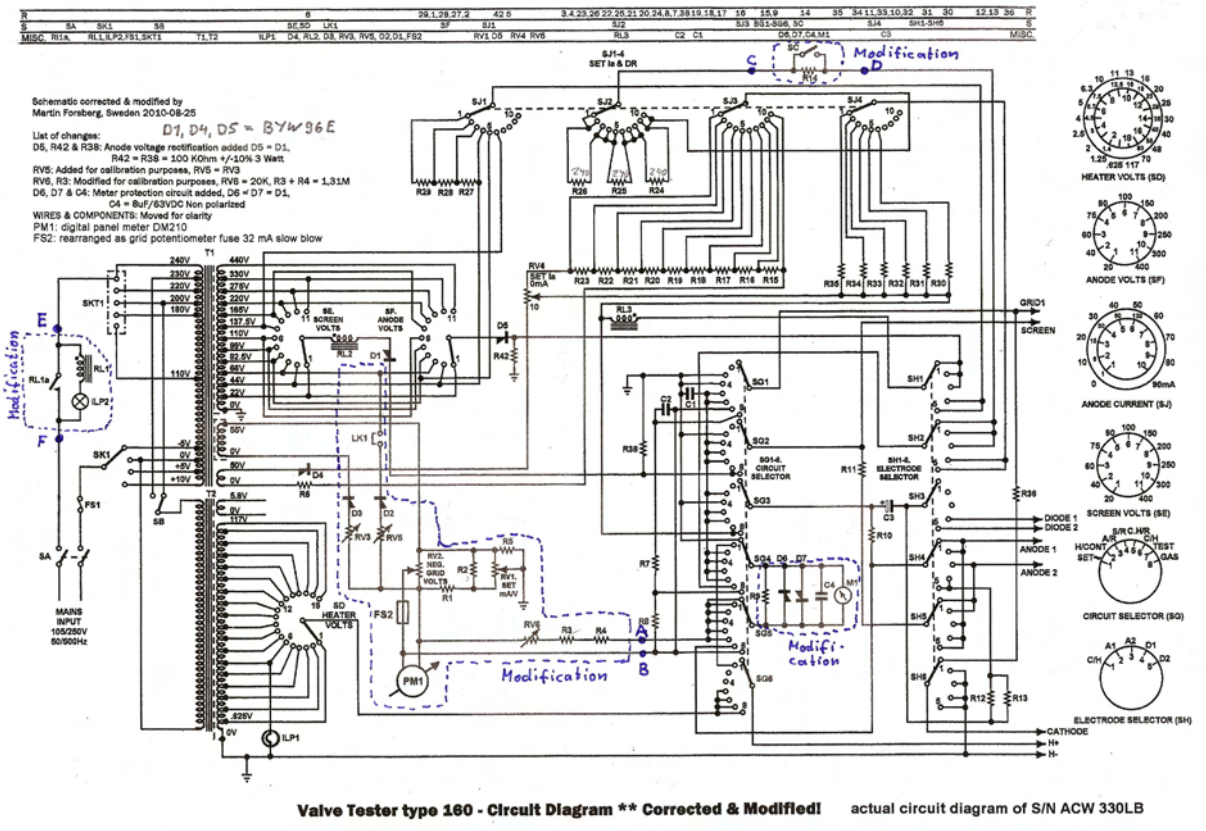

Fig. 1 – Diagram of original circuit with indicated areas of modification

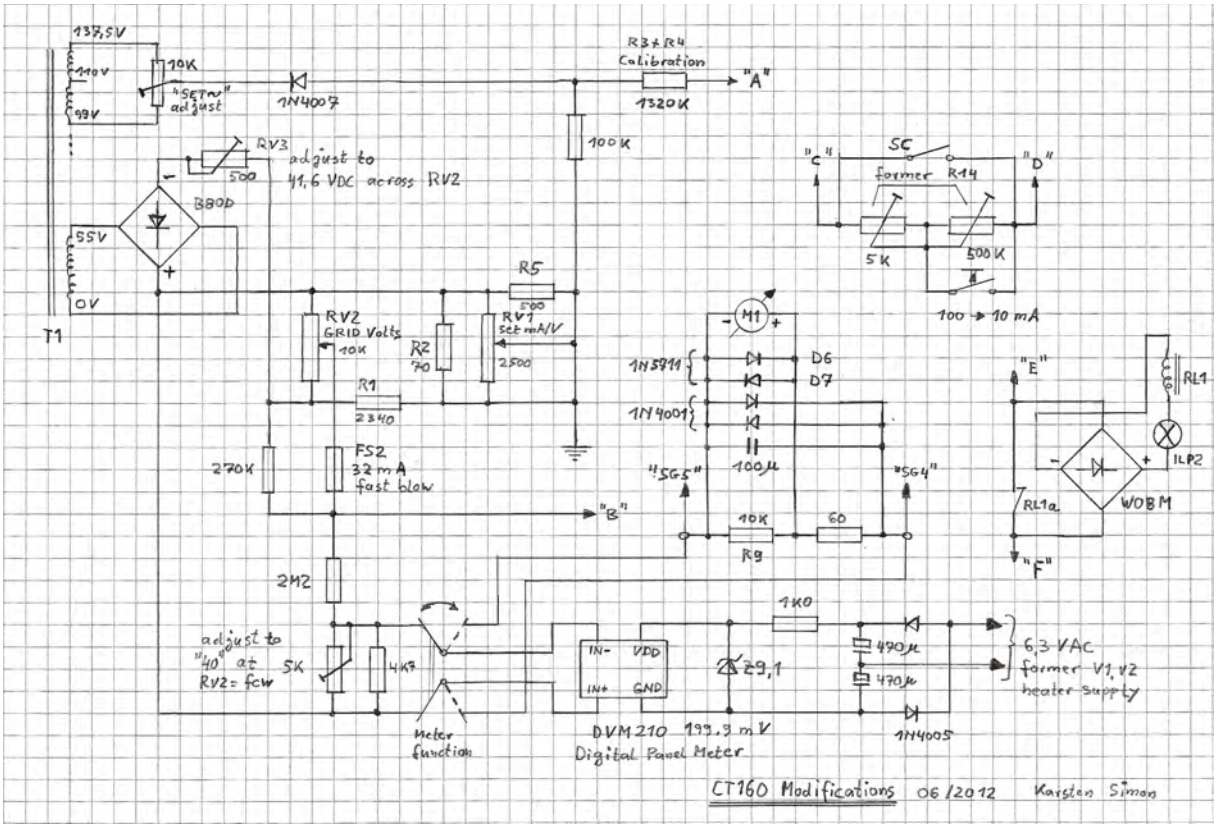

Fig. 2 – Modifications of original circuit

Replacement of Grid Voltage Potentiometer

The burnt 10 KOhm potentiometer RV2 was replaced by a vintage surplus MIL grade wire wound single turn potentiometer (Waters Mfg. Inc., Ebay) and a 3½ digit 199.9 mV digital panel meter (DVM 210, Conrad).

Measurement of Grid Voltage

Accurate measurement of the grid voltage requires separation of the transformer T1 secondary supplies for grid and calibration. The grid voltage is full wave rectified by a B80D bridge rectifier. Full wave rectification is necessary because with only half wave rectification the tube under test will sink approx. 100 uA grid current during the zero anode current cycle, dependent on tube type. This current causes a voltage drop on the RV2 wiper which falsifies the panel meter reading. With full wave rectification the grid current becomes negligible.
The DVM 210 requires isolated 9 VDC which is supplied from the now unused EB91 heater winding by a voltage doubler.

Grid Voltage Potentiometer Protection

For protection against destructive currents on the potentiometer wiper (caused by erroneous setting of Roller Selector switch or faulty valve with inter electrode shorts) the second front panel fuse FS2 has been rewired in series with the wiper and fitted with a 32 mA fast blow fuse. This leaves only one fuse in the mains input circuit which is still compliant with most (if not all) national electrical safety regulations.
If the fuse blows the 270 KOhm resistor will help to protect the tube under test by pulling the grid potential to -32 V.

Digital Panel Meter Function Selector Switch

A dpdt toggle switch permits switching of the DVM 210 between grid voltage display and analogue meter reading. This is particularly convenient when backing off anode current as the meter displays negative values with a "-" sign.

The analogue meter reads full scale at 97.5 mV = 100 scale divisions on the uA Ig scale. For easy comparison the DVM should also display "100.0" at analogue meter full scale deflection. Rather than employing a disproportionately elaborate op amp circuit this small difference of 2.5 mV is made up for by a single 60 Ohm resistor in series with the 10 KOhm shunt resistor R9. Without the resistor large values show a discernible difference between analogue and digital readings and will tempt you to fiddle with the mechanical zero screw.
The error caused by this small series resistor can be eliminated by proper alignment on all measuring functions except Anode current backing off. Here the reading error for the 1 mA/V mark caused by the additional series resistor is +1.75%. However, the internal resistance of the 9 position bridge ladder R15 … R23 is compensated by only three grouped resistors R24 … R26 which already causes an inherent error of +-2.4% for the 1 mA/V reading. AVO states the overall accuracy of the tester as +-5%. So the additional +1.75% will shift the overall error to +-5% + 1.75% = -3.25% … +6.75% which is negligible in practical work.

Analogue Meter Protection

The meter is protected by a damping capacitor and four clamping diodes as described in the forum thread http://www.vintage-radio.net/forum/showthread.php?t=55782&page=3 .

Calibration Voltage

The half wave rectified negative calibration voltage is taken from the 99 V and 137.5 V taps of T1 via a 10 KOhm trimpot. The circuit is similar to the one in the CT160A. At nominal mains voltage (use a variac) the trimpot is adjusted to the SET ~ mark (= 90% f.s.) on the analogue meter = "90.0" on the digital panel meter.

Replacement of Backing Off Potentiometer

The worn out wire wound 90 Ohm potentiometer was replaced by a conductive plastic type with 100 Ohm nominal resistance. It actually measured 95 Ohm. Excel Linear Regression yielded a 730 Ohm parallel resistor as optimum to bring its setting into accurate alignment with the etched markings on the panel.
In practical use the conductive plastic potentiometer has turned out to be superior to the original wire wound type in terms of sensitivity and setting precision, probably because of its inherently infinite resolution.

Direct Measurement of Anode Current

Resistor R14 was replaced by a 5 KOhm and a 500 KOhm trimpot in series. The 500 KOhm trimpot can be switched out by a normally open pushbutton contact on the front panel. With the mA/V dial parked and the anode current backing off controls at zero the trimpots are adjusted to 10 mA f.s. with pushbutton depressed (100 mA f.s. with button released). This modification greatly assists in backing off an unknown anode current and avoids the need for an external meter in most cases.
A similar modification has been described in the forum by Craig Sawyers:
http://www.vintage-radio.net/forum/showthread.php?t=78402&highlight=ct160 .

Overload Relay and Red Lamp LP2

The open relay coil RL1 was rewound by a professional electric motor repair shop. The lamp was replaced by a Paulmann type 800.11.
A W08M bridge rectifier was inserted between the relay contact and the RL1 – LP2 series circuit. This greatly reduces contact arcing but also makes relay action rather quiet. However, whenever the relay contact moves the digital display begins to flicker and show irregular values. This catches immediate attention and is a good alternative to the former loud relay chatter.
The relay spring carries the full lamp current when the contact opens. This can cause the spring wire to heat up and completely loose its elasticity rendering the spring useless. I have

soldered a thin and flexible silicone isolated laboratory cable from the connection on the relay socket up to the moving arm. Make the connection to the arm close to its tilting line in order to minimize motion in the cable.

External Valve Connection Leads

Two new leads were made from short pieces of suitably isolated cables with moulded on 2.5 mm mono barrel plugs. The outer diameter of this plug is only slightly too thin and was made to fit into the connector panel sockets by soldering a thin strip of copper foil (used for Tiffany glasswork) onto it. The valve connection clip is a battery type (Conrad #736619). See Fig. 3 for details.

Fig. 3 – Barrel plug and valve connection clip

Tester Panel and Valve Holder Panel

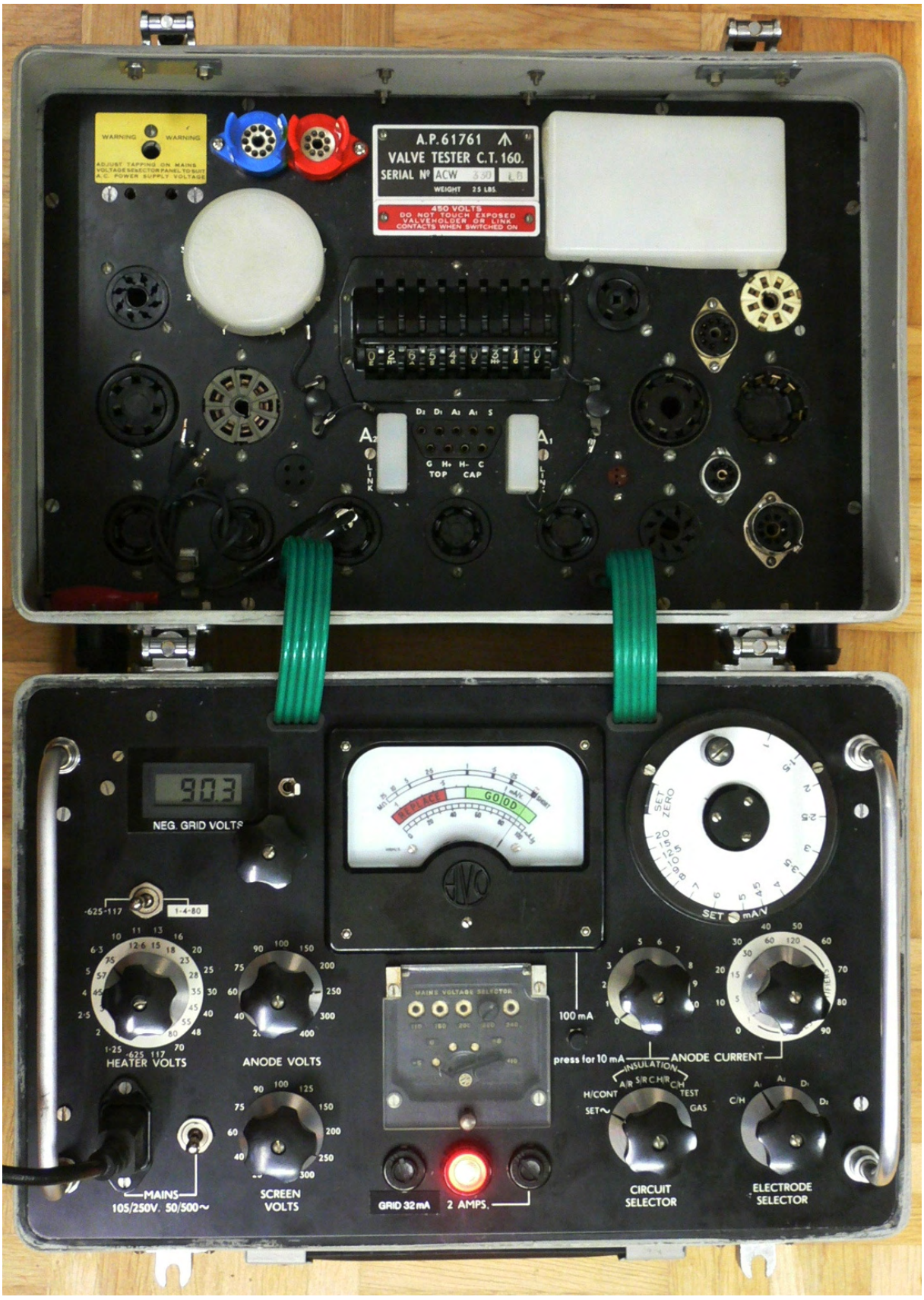

Fig. 4 – Modified tester panel and valve holder panel

The digital meter has been mounted at the position of the original Vg dial. The surrounding anodized aluminium frame covers the hole in the panel behind the scale. The new Vg potentiometer is mounted in place of the bushing for the drive knob of the original dial drive.

The function selector switch is mounted in the existing bore to the right of the former dial. It is toggled horizontally: left pos. = Ug display, right pos. = analogue meter display.

The Anode current range select button is mounted to the right of the voltage selector.

A set of pin straighteners (Dieter Wächter) has been mounted on the valve holder panel in the free space above the covered flying lead valve holder.
A Schuko socket insert has been mounted on the valve holder panel behind the two holes for the mains plug prongs. This will hold the power cord plug when the tester is folded up and stored away.

(Ende)