

# REFURBISHMENT and VERIFICATION of the HEATHKIT TT-1 TUBE TESTER

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Dedicated to the memory of Lloyd Generoux, who introduced me to the wonders of old technology.

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The Heathkit TT-1 Assembly and Operating manuals are arranged logically enough for the original kit builder but since the TT-1 is likely acquired in an aged and already assembled state, refurbishment and verification become the first issues. It can be tough to say which of refurbishment or verification comes first. If you are impatient (like me) to verify and wish to fire up a unit for the first time in decades before refurbishment, make sure that the proper (2 Amp) fuse is installed before turning it on. Supply caps in particular can become quite cranky after many idle years.

***Disclaimer: Dangerously high voltages (up to a few hundred volts) exist at accessible points in the Heathkit TT-1 chassis. Only those competent in high voltage electronics practice should remove the TT-1 chassis from its case. This document is the author's personal reference and report. Effort has been made to check for accuracy and safety, but ANY READER WHO WISHES TO ADOPT THIS DOCUMENT AS A GUIDE DOES SO AT THEIR OWN RISK!***

## PART 1: REFURBISHMENT

Most components in the TT-1, especially capacitors, resistors and contacts, are subject to age and will require checking or replacing before operation (coils, transformers and the meter should stand up to age pretty well). A list of relevant parts is included at the bottom of this document. Borrowing conventional advice for antique electronics, I did the following:

- Replaced all electrolytic (polarized) capacitors with modern electrolytics, and paper capacitors (such as the black plastic tubular types) with film or ceramic types. This meant pretty well all the caps in the TT-1 but fortunately good modern caps are cheap and easy to find. All the electrolytic caps in the TT-1 (i.e. with values larger than a few microfarads (uF)) are for supply filtering, so they can be replaced with caps of at least the original voltage rating and up to twice the capacitance. I chose high temperature (105 deg. C.) electrolytics for greater reliability. Most of the other capacitors are for AC coupling, and can be replaced with caps with at least the original voltage rating and within 25% of the original value. The exception to this is the 0.22uF calibration cap located behind the calibration switch: it is a 2% precision type that can be verified in situ with a capacitance meter if the "Calibration" knob is turned to "Bias" or "Operate". It looks like a quality part and checked fine on my TT-1.

The 0.02uF 600V cap sets the AC signal frequency (5kHz nominal, but is 7kHz on my TT-1), and every 20% change in value will change the frequency about 10%. The 0.1uF cap to the meter will affect calibration somewhat. Small shifts in frequency and meter response are compensated in calibration, however, so +/-25% is still plenty accurate for replacing these two components.

- Disconnected the AC capacitor. This AC cap is used as a series element to set the 300, 450 and 600mA filament supplies, and this relies on a high tolerance (better than 5%). Not only did the AC cap in my unit triple in value with age (which would have accordingly tripled intended filament current), but it started to heat up and bulge in minutes when loaded! Since I see few circuits with current driven tube filaments, however, running them from an appropriate voltage instead should be sufficient. If the AC cap must be replaced, the best choice is probably polystyrene film types **which are AC rated** for 150 VAC or more (non AC rated caps may overheat and do ugly things!). These can also be paralleled to yield exact values, but such caps are not particularly cheap or compact.
- Replaced out of spec carbon resistors. Carbon resistors tend to change over time toward the high side. Fortunately most are electrically open on at least one end and can be checked in situ with an ohm-meter. Any resistor found outside its tolerance (most are 10%) can be replaced with a new resistor of equal power dissipation rating (metal film types if possible). Be aware that carbon resistors that initially check fine may increase their value significantly after being heated, such as when an adjacent component is soldered, so recheck any old resistors you leave in after you've changed parts! Happily, I found that the precision resistors on my TT-1 were still within their 1% tolerance.
- Replaced diodes. The original CR-101 silicon rectifiers are not very rugged, and I found a couple of bad ones. Modern 1N4007 diodes are cheap and superior. I just clipped one end of the original diode away and bridged the leads with the new part (Note: the red end of the old diode is the cathode!) For purists who want to leave the old diodes in, a good CR-101 measures about 0.45V with 1mA forward current (same as typical silicon diodes).
- Cleaned all contacts. Contacts get covered with oxides and gunk over the years. I sprayed switches and inside potentiometers with contact cleaner, then rotated them over the full range a few times. An ohmmeter placed between one end of a pot and the centre wiper terminal will show smoothly changing resistance as the control is turned if the pot is clean (this is where a needle type meter is great) and jump around in value if not. Most pots have a strip of carbon inside and shouldn't be treated too roughly, but rheostat windings (such as on the LINE SET and METER pots) can be scrubbed with a Q-Tip and contact cleaner (I removed the back plate off of the METER control to clean it as well). The slide switches on my unit were stiff and balky at first, but a few sprays of flux cleaner and contact cleaner inside, applied over a few days along with some periodic actuation, got these working very smoothly (mechanically and electrically). Where convenient, switch contacts should be checked for a very low contact resistance that doesn't change when the switch is wiggled sideways. Tube socket contacts were cleaned with a pipe cleaner (something a bit tougher would have been nice) and contact cleaner. Any switch or control that remains intermittent after a while should be replaced, as these can damage a tube under test with transient conditions.
- Replaced tube sockets. In my case, the miniature 7 and 9 pin sockets were worn to the point of loose, intermittent contact during test. I could not readily find a replacement for the 9 pin socket, so I replaced the contacts with those removed

from a junk box socket.

As for cosmetics, bolts on the aluminium instrument panel may have a white crust ("metal mold"), and I'm told that nickel plate does this over time with humidity when in contact with aluminium. This can be removed with a stiff brush.

Following is a list of components taken from the Heathkit TT-1 Operational Manual:

Qty. Value

#### Resistors

1	47 ohm 1/2 watt
1	2.7 Kohm 1/2 watt
1	4.7 Kohm 1/2 watt
1	150 Kohm 1/2 watt
1	18 Megohm 1/2 watt
1	1.8 Kohm 1/2 watt
1	100 ohm 1/2 watt 5%
1	620 ohm 1/2 watt 5%
1	100 Kohm 1 watt
1	2.0 Kohm 1 watt 5%
1	4.3 Kohm 1 watt 5%
2	3.0 Kohm 1 watt 5%
1	47 Kohm 2 watt
1	10 Kohm precision (1%)
1	200 Kohm precision
1	1.0 Kohm precision
1	225 Kohm precision
1	500 ohm precision
1	710 ohm precision
2	250 ohm precision
1	190 Kohm precision
1	133 Kohm precision
1	2.24 Kohm precision
1	360 ohm 7 watt
2	2.0 Kohm 10 watt

#### Controls (potentiometers and rheostats)

2	10 Kohm linear (tab mount)
1	10 Kohm linear (screwdriver adjust)
1	7.5 Kohm linear
1	7.5 Kohm linear (semi-precision)
1	350 ohm 25 watt

#### Capacitors

1	.02 uF 600 volt
2	.5 uF 400 volt
1	.1 uF 400 volt
1	.05 uF 200 volt
1	.22 uF 200 volt 2%
3	20 uF 350 volts
1	40 uF 150 volts

- 2 100 uF 50 volts
- 2 25 uF 25 volts
  
- 1 3-section AC: 3.6 uF, 3.6 uF, 7.1 uF, 125 VAC

## PART 2: VERIFICATION

This section is taken from the Heathkit TT-1 Assembly Manual (added comments in square brackets). **The Figure at the end of this document combines pertinent parts from the Manual. The reader can refer to it at his/her own risk.** Test points are named as an entity and pin number (for example, "SR2" means lug 2 on switch SR in the Figure at end of document). This procedure was meant as a basic check of operation after assembly, and it's a useful guide to checking out a used TT-1:

The CALIBRATE switch should be in the OPERATE position during the testing procedure. The P, G and K switches should be in position 1. The DISCONNECT and LIFE TEST switches should be in the NORMAL position, the LEAKAGE switch in TUBE TEST position, and the PLATE switch in position D. Other switch and control positions will be called for as required. BE SURE to observe normal safety precautions during testing of this instrument. Disconnect power when making connections to terminals (connecting meter leads, etc.).

Ohmmeter and continuity readings may be difficult to make due to the complexity of the tube tester switching. In no case, however, should there be DC continuity shown from the circuitry to the chassis or panel. The only connection to chassis ground are the common terminals of the oscillation suppressors (P.E.C.'s). A connection between chassis and any other point indicates incorrect wiring or a faulty component.

In the event the unit does not perform as outlined in the testing procedure, troubleshooting is greatly simplified by comparing the wiring of the switches, transformer, etc, with the terminal code data shown on the Schematic Diagram.

### 1. LINE CONTROL CIRCUIT

Plug the line cord into a 105-125 volt 60 cycle AC source and move the OFF-ON switch to the ON position. The panel lamps should light to a normal brightness level with the SET LINE control at the halfway point of its rotation. Turning the SET LINE control clockwise from this position should brighten the panel lamps. Turning the SET LINE control counterclockwise should cause the panel lamps to dim.

Pull down the LINE TEST switch. The meter should deflect upscale. The reading of the meter will be dependent upon the position of the SET LINE control, a clockwise rotation of the control producing an increase in meter indication. Assuming an input voltage of 117 volts, the meter indication should vary from approximately ¼" to the left of the LINE CHECK arrow at midscale (maximum counterclockwise position of SET LINE control) to about ½" to the right of the arrow (maximum clockwise position of the SET LINE control).

### 2. FILAMENT SUPPLY CIRCUIT

Connect the leads of an AC voltmeter to SX21 (see Figure) and CD1 (see Figure) (use the 150 volt range or higher). Turn the instrument ON and adjust the line voltage (pull down the LINE TEST switch and adjust the meter to the LINE CHECK arrow with the SET LINE control).

For all voltage positions of the FILAMENT switch, the voltmeter should read essentially the same voltage as that shown on the PANEL. The important consideration is that the voltmeter reading should increase with each successive clockwise step of the FILAMENT switch. If the voltmeter shows a decrease when the switch is rotated clockwise, the switch has been incorrectly wired. If this situation occurs, it should be corrected before proceeding further.

With the FILAMENT switch at any convenient voltage position, depressing the LIFE switch should decrease the voltmeter reading by approximately 10%.

[If the AC capacitor used to generate the 300, 450 and 600mA filament current drives has been removed is suspect, as described in the refurbishment section, skip the filament current drive test below.]

Select a tube designed for series string hookup (heater current 600mA preferred) and set the SELECTOR switches corresponding to the heater connections to positions 6 and 7, respectively. Set all other SELECTOR switches to 0. The top row of SELECTOR switches corresponds to tube pin 1 through 5, starting at the left. The bottom row corresponds to tube pins 6 through 9, starting at the left. Turn the filament switch to the correct current position.

Now plug in the tube. It will probably be necessary to readjust the SET LINE control. The voltmeter should now indicate essentially the same voltage as that listed for the particular tube you are using. Here again, depressing the LIFE switch should decrease the voltage reading by approximately 10%.

If everything is operating as outlined above, the filament supply circuit has been correctly wired. Remove the tube and go on to the plate voltage testing section.

### **3. PLATE VOLTAGE SUPPLY**

Connect the leads of the AC voltmeter to SP2 and SQ2 (see Figure). The voltmeter should indicate as shown below for various positions of the PLATE switch.

Position A 20 V AC  
Position B 45 V AC  
Position E 177 V AC

Connect a DC voltmeter to SP2 and SQ2 (negative to SP2). The voltmeter should indicate as shown below for various positions of the PLATE switch:

Position O 26 V DC  
Position C 90 V DC  
Position D 135 V DC  
Position F 225 V DC

Remove the voltmeter leads and put the PLATE switch in position G. This connects the variable DC supply used for voltage regulator testing. This supply is constantly monitored by the TT-1 meter, which should now be reading the value of the voltage applied to the plate circuit of the tester. This voltage may be varied by either the FILAMENT switch or the SET LINE control. If either one or both fails to change the

value of the meter reading or if no reading is present, check the wiring of the PLATE switch and associated circuitry before proceeding.

Connect a DC voltmeter to point "L2" in the Figure and "SX17", with negative to L2. The voltmeter should indicate 26 V DC. This voltage supply is connected to the space charge grid of space charge grid tubes.

#### 4. BIAS VOLTAGE SUPPLY

Connect the leads of a DC voltmeter to SP2 and SR2 (negative to SR2). Place the BIAS RANGE switch in the L (low) position and the BIAS control maximum clockwise. Turn the internal bias adjust control CD throughout its entire rotation. The voltmeter should indicate from 0 to 20 volts, depending on the setting of CD. Adjust CD to give a voltmeter reading of approximately 5 volts.

Now turn the BIAS control on the front of the panel. This should vary the voltmeter reading from 0V (maximum counterclockwise) to 5 V (maximum clockwise). Now change the BIAS RANGE switch to the H (high) position. Rotation of the BIAS control should now give a voltmeter indication from, 0 to 20 volts. Remove voltmeter leads.

#### 5. LEAKAGE TESTING CIRCUIT

Set the instrument controls as shown below. These are the settings for a 6AU6 tube:

PLATE	C
FILAMENT	6.3
SELECTORS	52763-4100
BIAS	9L
METER	45
SIGNAL	4

Select a convenient value of resistance (preferably between 100 K and 500 K ohms). With this resistor between pins 4 and 7 of any of the tube sockets, the meter should indicate the resistance value directly on the LEAKAGE meter scale when the LEAKAGE switch is in the #1 position. Move the LEAKAGE switch to position 2 - the meter pointer should return to its rest position. Now move the resistor to pins 2 and 7. The resistance reading should now reappear on the meter, Check the remaining positions of the LEAKAGE switch as shown below:

Switch Pos'n	Resistor between
3	Pins 5 and 7
4	Pins 6 and 7
5	Pins 1 and 7

If the leakage testing circuit does not operate as outlined above, recheck the wiring of the LEAKAGE switch and associated circuitry before continuing the testing procedure, otherwise, remove resistor.

NOTE: The meter pointer will normally be a little above zero with the LEAKAGE switch in position 2, 3, 4, or 5.

#### 6. TUBE SOCKET AND SELECTOR SWITCH WIRING

Place the LEAKAGE switch in the TUBE TEST position. The other controls should be positioned as outlined in the previous section. The instrument is now set up to test a 6AU6. With the negative lead of a DC voltmeter connected to pin 7 of any of the tube sockets, you should measure the following voltages at the pin numbers indicated.

Pin No.	Voltage
1	-1 volt (approx)
2	0 volts
5	+90 volts +/-10%
6	+90 volts +/-10%

An AC voltmeter connected between pins 3 and 4 should indicate approximately 6 volts AC.

Operation of the DISCONNECT switch should reduce the above listed voltage readings to 0.

## 7. Gm TESTING CIRCUIT

[While the original Heathkit instructions specify using a 6AU6 here, any small normal triode or pentode (e.g. 12AU7, 6AQ5) will serve for this test as long as the instrument is set up correctly for that tube's triode or pentode mode according to the TT-1 tube list.]

Insert a 6AU6 tube which is known to be good in the proper socket and allow it to warm up (knob positions should be as indicated in section 5). While it is heating, position the two tab mounted controls CF and CG (mounted on the subchassis) at the midpoint of rotation. The METER control should now be turned maximum counterclockwise (0).

Pull down the Gm test switch; the meter should now deflect up-scale. The meter reading should increase and decrease accordingly as CF and CG are varied. Changing the position of the SIGNAL switch should also cause a variation in meter reading, a decrease in meter reading corresponding to clockwise motion of the SIGNAL switch. This action should also occur as the METER control is varied, an increase in meter reading corresponding to clockwise rotation of the control.

If no meter reading is obtained during this test, the oscillator transformer connections, oscillator tube socket connections, oscillator tube (3A4) and choke connections could be possible sources of trouble. Remove the 6AU6 tube.

## 8. GRID CURRENT TESTING CIRCUIT

Turn the PLATE switch to position "O". Connect a large resistance value (22 megohms or higher) from SR2 to SQ2. Turn the instrument on and allow a few minutes for the 12AV6 tube to heat.

Turn the GRID CURRENT switch to the TEST position and hold it there. The meter should deflect up-scale.

If no meter reading is observed during this test, the GRID CURRENT switch wiring and associated circuitry should be checked carefully. Remove the resistor between SR2 and SQ2 before proceeding further.

## 9. RECTIFIER AND DIODE TESTING

[While the original Heathkit instructions specify using a 6AL5 here, any small diode tube, or tube incorporating a diode, will serve for this test as long as the instrument is set up correctly for that tube's diode mode according to the TT-1 tube list.]

Set the panel controls as shown below. These are the settings used for testing a 6AL5 tube:

Plate	A
Filament	6.3
Selectors	K3761-2P00
Meter	39

Insert a 6AL5 tube which is known to be good into the proper socket. After allowing sufficient time for the tube to heat, pull down the AMPL.-RECT. and DIODES switch to the RECT and DIODES position. The meter should deflect upscale into the section marked "DIODES O.K." Remove the 6AL5 tube.

## 10. CALIBRATION CIRCUIT

Turn the CALIBRATE switch to position 1 (BIAS) and the BIAS controls to 20L; the meter should deflect upscale. This meter reading should increase or decrease accordingly as CD is varied.

Turn the BIAS control to 0, change the CALIBRATE switch to position 2 (SIGNAL), and pull down the Gm test switch. The meter reading with the CALIBRATE switch in this position should change with rotation of control CG.

Turn the METER control maximum clockwise and change the CALIBRATE switch to position 3 (METER). The PLATE SWITCH should be in position C. Pull down the Gm test switch. The meter reading should vary with rotation of control CF.

Return the CALIBRATE switch to the OPERATE position.

The following section is taken from the last few pages of the Heathkit TT-1 Operating Manual:

### **TRANSFORMER VOLTAGE CHECK**

With SET LINE adjusted to give a 100VAC reading between terminals 10 and 14, an AC voltmeter should read within 10% of the following voltages between the given terminals. The manual specifies a 5Kohm/V meter but I saw no problem using a modern high impedance digital meter:

Terms Voltage	Terms Voltage
1-2 3	21-8 2.0
1-30 3.3	21-9 1.5
10-11 196	21-22 0.65
10-12 177	21-23 1.1

10-13	111	21-24	3.3
10-14	100	21-25	5.0
10-15	75	21-26	47
10-16	67.5	21-27	70
10-17	50	21-28	115
10-18	45	21-29	120
10-19	22.5	21-31	13
10-20	20	21-32	20
21-3	35	21-33	27.5
21-4	10	35-34	14
21-5	7.5	35-36	100
21-6	6.3	35-37	130
21-7	2.5	38-39	16
38-40	17.8		

### ***INSTRUMENT TUBE TESTING***

A high impedance DC meter (such as a modern digital) should read close to the following voltages when the negative and positive leads are placed as directed:

#### **3A4** (oscillator tube for AC grid signal)

Make the following measurements with the Gm switch in test position [placing the negative and positive probes at points in column “Neg” and “Pos”, respectively]:

Neg	Pos	Voltage
Pin 1, 3A4	Pin 2, 3A4	+30VDC
Pin 1, 3A4	A6(subchassis)	+70VDC
Pin 1, 3A4	Pin 4, 3A4	-15VDC
Pin 1, 3A4	R1(under chassis)	-15VDC
Pin 1, 3A4	Pin 7, 3A4	2.8VAC

#### **12AV6** (grid current detector)

Make the following measurements with the GRID CURRENT switch in TEST position:

Neg	Pos	Voltage
Pin 2, 12AV6	Pin 7, 12AV6	+160VDC
Pin 2, 12AV6	R2(under chassis)	+155VDC
Pin 2, 12AV6	M1(under chassis)	-5VDC
Pin 2, 12AV6	Pin 4, 12AV6	12VAC

[These tubes should be tested, presumably on another tester!]

