THE PAT-4 TREBLE CONTROL

The first article in this series was on the bass control potentiometer. It had an unusual resistance versus wiper-position characteristic. The treble control has a different, but still very unusual configuration. All these different pot tapers go back to their decision to use a non-Baxandall tone control topology, essentially wrapping the tone controls around a discrete (2 transistor) non-inverting mode op-amp. Please refer to the "PAT-4 Bass Control" document for more information contrasting the PAT-4 topology with the standard Baxandall topology.

Suffice it to say that the pot is quite non-standard. For common terminology, we'll call the ends terminals 1 and 3, and the wiper terminal 2. Here is a summary of the unusual aspects of the control:

1. There is not a continuous resistance from terminal 1 to 3.
2. From 45% of the rotation to 55% of the rotation, the wiper, terminal 2, is open circuited.
3. The two halves of the pot, from terminal 1 to 2, and from terminal 2-3, have different maximum resistances.

It turns out that Dynaco has telegraphed the intention of the treble pot across the years by the way they drew the pot in the schematic. Notice the open circuit in the center of the pot. It is real...it is not a drawing error, misprint, or smudge.

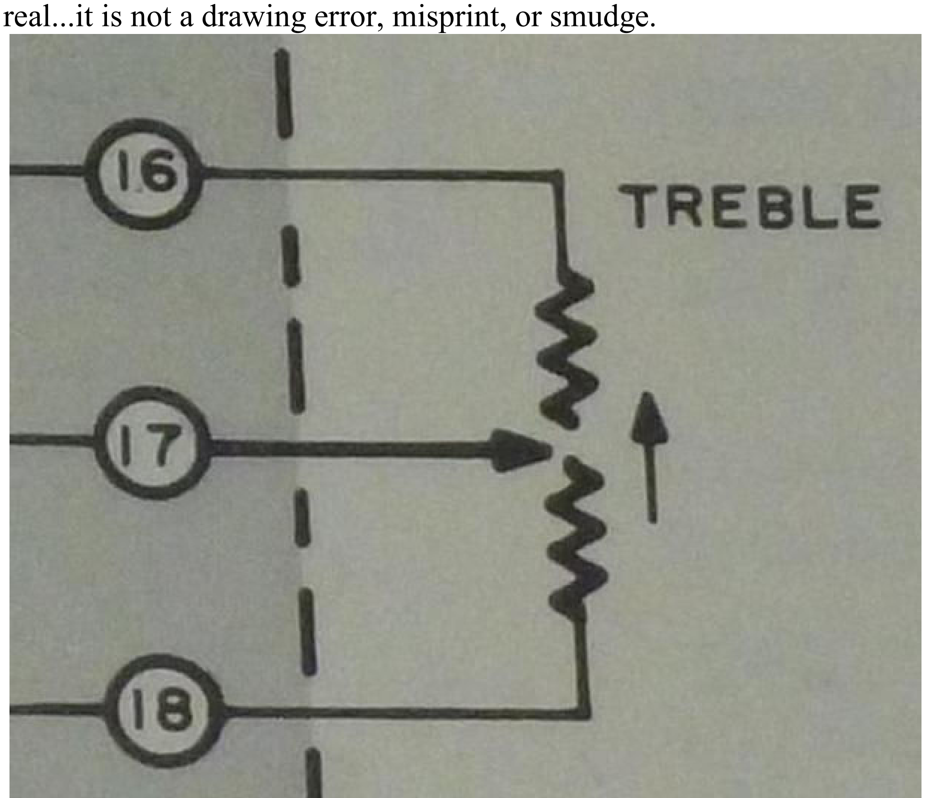

Figure 1 – close-up of the drawing of the treble pot in the PAT-4 schematic clearly shows the break in the center of the resistive element

The more usual things are:

1. the resistance increases exponentially with rotation
2. dual concentric shafts provide independent control of both channels

The good news:

- For about 10% of the rotation of the pot, where the wiper is open, the treble control has no effect at all, so with careful centering, the tone control is completely out of the circuit in that 10% range.
- A later section of this paper shows how to assure that the 12 o'clock setting corresponds to the no effect (flat frequency response) setting of the treble control.

The bad news:

- Owing to its unusual nature, if the treble pot fails, you will find it very difficult to find a replacement except out of another PAT-4.

<u>Treble Pot Electrical Measurements</u>

I removed a treble control from a PAT-4 and measured the behavior of the resistance between its terminals. The pots have about 230 degrees of rotation. Fully counter clock wise is 0% rotation. Fully clockwise is 230 degrees, equal to 100% rotation. The appendix shows the resistance versus position characteristics of terminals 1-2 and terminals 2-3.

I verified the measured behavior by running a simulation with various positions of the treble pot. The simulation results supported the measurements.

<u>Centering the Treble Control</u>

Understanding what we now do about the behavior of the treble control, it's fairly easy to center the control, that is, to find the position where the treble response is flat. Basically, we're going to use an ohm-meter to find the limits of the 10% of the shaft rotation where the wiper (pin 2) is disconnected from both ends (terminals 1 and 3). We'll then set the knobs for 12 o'clock when the shaft is in the center of this region.

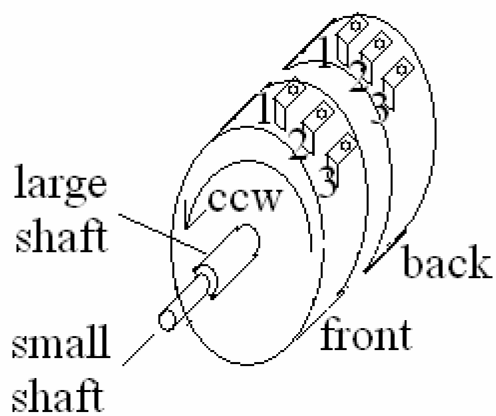

Figure 2 – treble control

Refer to Figure 2 so we can synchronize our terminology. Here are the steps. Assuming no leaky capacitors, there is no need to remove the pot to do this adjustment. In fact, it's better to leave it in place in the preamp.

1. Both treble knobs should be secured to their respective shafts. Cut a treble knob-sized hole in a piece of paper, placing the paper over the knob, and taping it to the front panel.
2. Turn the small shaft fully counter clockwise and mark its position on the paper with a radial line, labeling that line CCW.
3. Connect your ohm-meter (use alligator clips) to pins 2 and 3 of the back section. If your pot is working correctly, the ohm-meter should read just a few ohms.
4. Slowly turn the small shaft clockwise while noting the ohmmeter reading. At some point, a small incremental rotation will make the resistance jump up to an open circuit. Mark this point on the paper with a radial line, labeling it "1". You may want to search for the point a few times to be certain of its position. The last ohm-meter reading you'll get before the infinite reading will be in the range of 20 to 30 kOhms.
5. Move the ohm-meter to back-section terminals 1 and 2, and rotate the small shaft knob fully clockwise. The ohm-meter should read just a few ohms.
6. Slowly turn the small shaft counter clockwise. You're watching for the point where the terminal 1 to 2 resistance jumps up from 4 or 5 kOhms to an open circuit. Search a few times for this position, then mark it with a radial line, labeling it with a "2" when you're certain of its position.
7. The angular distance between the 1 and 2 mark should be about 20 to 30 degrees. In the next steps, we want to reposition the knob on the shaft to make the knob point straight up when the shaft position is midway between the 1 and 2 marks.
8. Make a radial mark halfway between the 1 and 2 marks, labeling it 3.
9. Estimate the angular distance between the 3 mark and a radial line through 12 o'clock on the point. Call that angular distance TC.
10. Starting at the CCW radial line, mark off the angular distance TC away from the line.
    a. If the 3 line is to the left of twelve o'clock, then mark the distance TC on the clockwise side of the CCW radial line.
    b. If the 3 line is to the right of twelve o'clock, then mark the distance TC on the counterclockwise side of the CCW radial line.
11. Mark this latest radial line, appropriately placed, with a star.
12. Turn the small shaft knob fully counter clockwise. Loosen the set-screw, and without moving the shaft from fully counter clockwise, align the treble knob indicator with the * radial line. Tighten the set screw.

Figure 3 shows a hypothetical mark-up according to the procedure. Of course, the exact positions of your lines will be different.

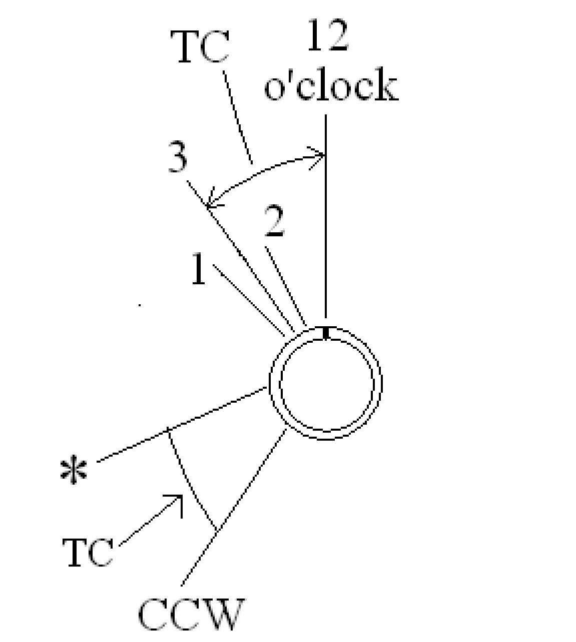

Figure 3 - * marks the new position for the CCW extreme of the pot's travel

Check your work. Set the knob to 12 o'clock. You should measure an open circuit from terminals 1-2 and from terminals 2-3. At this point, if you're looking for a quick answer, you could set the large shaft knob to match the small shaft knob. If you're rather more fastidious, you can set the large shaft knob using the same procedure as for the small shaft knob.

What if my control doesn't measure like yours did?

If the maximum resistance is off by 10 or 20%, that's not a cause for alarm. If it's off by more than that when measured in circuit, particularly if it's on the low side, you may have a leaky capacitor (I'd suspect C19 or C20). Note also that the maximum resistance is a bit hard to measure owing to the transition to infinite resistance.

To be sure about the measurement, you could remove two of the wires from the pot and repeat the measurements. If the result is still funny, you may have a problem.

Repairing the Most Common Problem with the Treble Control

The most common problem is a dirty control. You can repair this by spraying some contact/control cleaner and lubricant (I used some from Radio Shack) into the control. Spray each section of the control, followed by vigorous rotation of the control.

Warning: Make sure the power is off, and the PAT-4 is unplugged before you open it or service it. Further, allow some time for the power supply capacitors to discharge before working on the unit.

Figure 4 shows an extreme close-up of the treble control. The red tube is the extension tube on from the contact cleaner can. It is positioned to deliver contact cleaner to the insides of the control.

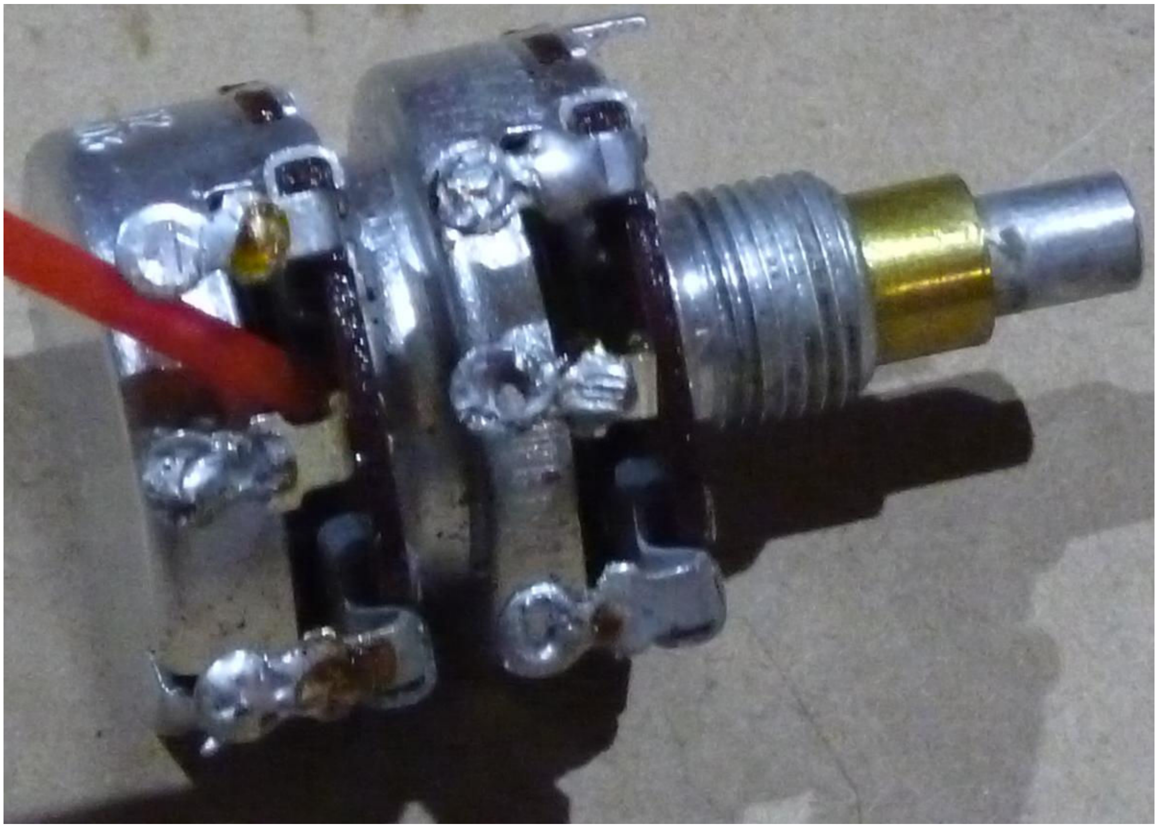

Figure 4 – Spraying contact cleaner into a control. Repeat for the section closer to the shaft.

APPENDIX – MEASUREMENT DATA

rot angle deg (0=CCW)	rot % (0=CCW)	res 1-2	res 2-3
0	0	5.00E+04	1
22	9.523809524	5.00E+04	366
40	17.31601732	5.00E+04	1390
64	27.70562771	5.00E+04	3260
83	35.93073593	5.00E+04	10410
99	42.85714286	5.00E+04	29000
105	45.45454545	5.00E+04	5.00E+04
125	54.11255411	5.00E+04	5.00E+04
130	56.27705628	4530	5.00E+04
146	63.2034632	2030	5.00E+04
165	71.42857143	1069	5.00E+04
180	77.92207792	742	5.00E+04
197	85.28138528	357	5.00E+04
217	93.93939394	110	5.00E+04
231	100	1	5.00E+04

Note that 5.00E+4 is a place-holder for infinite Ohms that makes the graph shown below more useful. In reality, every place that says 5.00E+4 should really say 100 MegOhms, or whatever practical approximation of an open circuit you like.