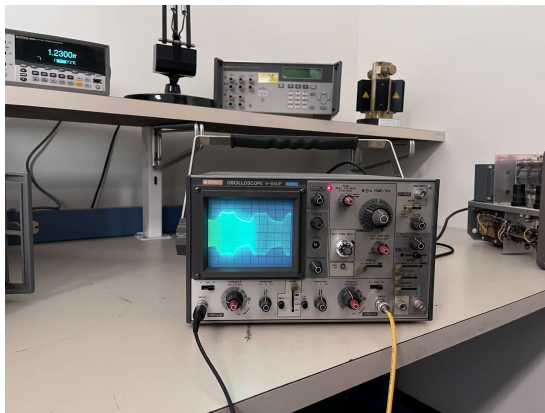


2/28/25: I've chosen my 9 week project as rebuilding this Hewlett Packard 200CD Oscillator. The goal is to get this oscillator functioning within its specifications after doing a calibration on it. The first part of this project includes doing an initial calibration to figure out what parts are not functioning up to spec. I am fortunate to have found a manual for this oscillator fit with a calibration procedure and schematics- as well as a parts list telling me each value of the components. Today I connected it to the calibrator and tested it in XY mode on the oscilloscope. Running the oscillator for about an hour the error had ended up at around .7% error read off of the calibrator. A few things to note from today was that the output sine wave was showing some noise from the AC power grid and I'd definitely like to get rid of that. Also the amplitude knob was very shaky when the amplitude was being changed. So that will need to be checked out as well. I was able to find some tubes on ebay so I could have some backups in the unforeseen circumstance one breaks. I have also found replacements for the electrolytic capacitors in the power supply and the one on the output of the amplifier. Ideally I would be able to design my own PCB layout in order to replace the can style capacitors.



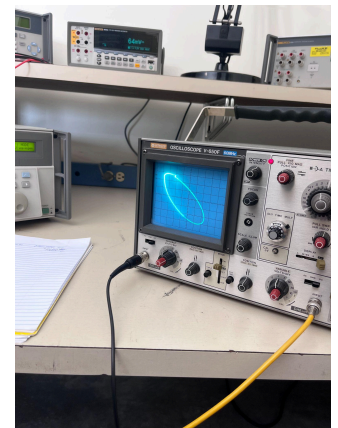
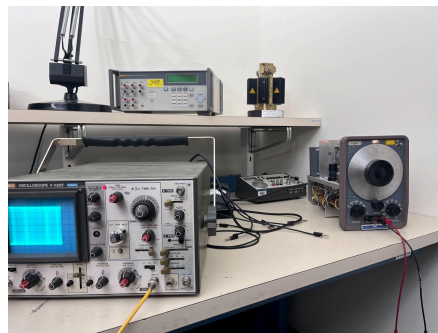
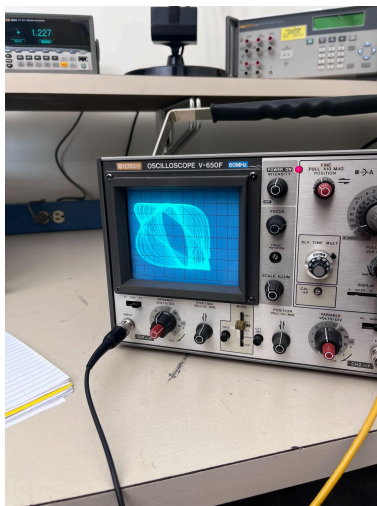
This is the AC noise on the output.

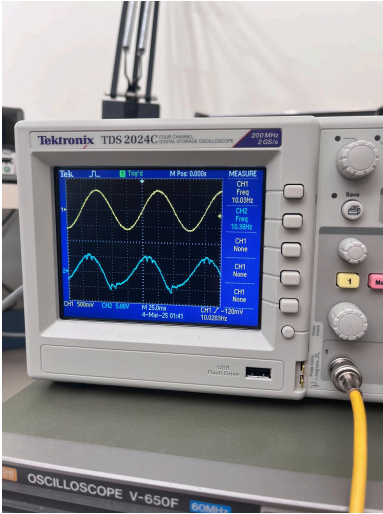


3/3/25: Today I started testing the frequency output of the oscillator. I came up with a few tables (one to measure each range of the frequencies so 5 total) The original plan was to dial up different frequencies at the top and bottom of the range using both the fluke calibrator and see when the lissajous figure would “spin” the slowest. This proved very difficult to measure at the high frequencies (500kHz) because of the noise seen on the oscillations. This method did work well at the low frequencies however. The data we collected was very spotty as we were not able to record enough data in the time allotted to each range. (meaning the time data was recorded might be 1-2 minutes before the time stamp stated, with upwards to 10 minutes after). The second idea was to scrap the lissajous figures all together and go with a digital scope to measure each channel and then subtract the difference between the 2 different frequencies. This worked somewhat well at the lower frequencies and not so well at the higher ones like before. Output amplitude has not been measured at this time. All digital scope readings happened at the 45+ minute mark.

Here are some things to note from this stage of measuring

1. The HP oscillator's output tends to vary based on scope readings. This seems to happen more and more as frequency goes up. Whether this be finding a slow moving lissajous and having it move faster without touching any frequency control or seeing a number measured by a digital oscilloscope changing it seems apparent using both types of scope.
2. The (which at this time we are blaming on tube heater noise or power supply) noise seen makes the high frequency lissajous difficult to capture.
3. Small amounts of distortion are seen at the peaks of the oscillator's output when set at 10 Hz.





3/4/25: Today I started testing the high voltage power supply based on what the schematic says I should see at certain places. Where I should be seeing 315 Volts AC on the transformer I am getting about 350-360 volts. On the other side of the rectifier tube I expected to find 350 volts DC and I was getting about 288 volts DC. A higher voltage on the AC side of the rectifier tube and a lower voltage on the DC side would mean that too high of a voltage drop is happening between the cathode and plate of the rectifier tube. Based on this information I would have to infer that the rectifier tube is weak (I also tested the 6.3 VAC output off of the transformer and it had the correct voltage) The troubleshooting guide also shows me that the rectifier tube might be to blame. (I am getting 269 VDC between the points described the lowest it can be while being in spec is 292.5 VDC)

a. Power supply not operating properly.

a. Check level of d-c voltage at power supply output; should be $325V \pm 10\%$. Use d-c voltmeter such as Model 410B; connect voltmeter + terminal to terminal 3 or 4 on capacitor C13, and voltmeter-terminal to C13 terminal 1.

a. Replace defective component.

If voltmeter indication not $325V \pm 10\%$, check rectifier tube V5, and then other components of power supply.

3/6/25: Ran more testing today- this was to pretty much complete the 60 range of frequencies, so far the data is showing that the frequencies are within spec on the X1 scale, but with the X10k scale the largest error seems to be up to 6.6%. I do not yet know if this is the X10 range itself or just because the frequency is so difficult to get a precise reading. More testing to come tomorrow.

3/7/25: Finished running the tests today and looking at the data it is difficult to see any singular cause as to why certain ranges test almost dead on and other ranges are as much as 7 percent in error. Robert showed me a few things in google sheets of how to average the data quickly and get a percentage error for all of my data without doing hand calculations of everything. The

percentage error is taken from an average of the 2 recordings that were taken after sufficient warmup time for calibration (average from 25-50 minute range). [HP 200CD Initial Data](#)
I believe that this data has no trends because of my previous mentioned point that the frequency output seems to be shifting around the selected frequency. This I believe to be caused by the amplifier tubes because the oscillations need a negative feedback signal that is reliable-if this feedback signal is not reliable, (bad tubes) it will tend to wander. Other cleaning will be needed as well and this includes blowing out the variable capacitors and cleaning the contacts on the rotary switch deck.

3/14/25: After being away from this project for a few days (from being sick and working on experiments) I had some parts come in. These being the new rectifier tube and capacitors for the power supply. I worked for a good half of today on experiments, which in hindsight may have been too much because I had not gotten as much done on my project as I had hoped. I did however start replacing the capacitors. I first made sure they were all discharged and then started cutting the wires to the capacitors. I removed the riveted plates that held the old style capacitors to the chassis. Robert printed me a part that will be used to hold the old shroud which now will protect the 3 capacitors inside C13. I am planning on using cable clamps to hold the other two capacitors in place (but Robert has given me the idea of printing another part so I will brainstorm that over the weekend).



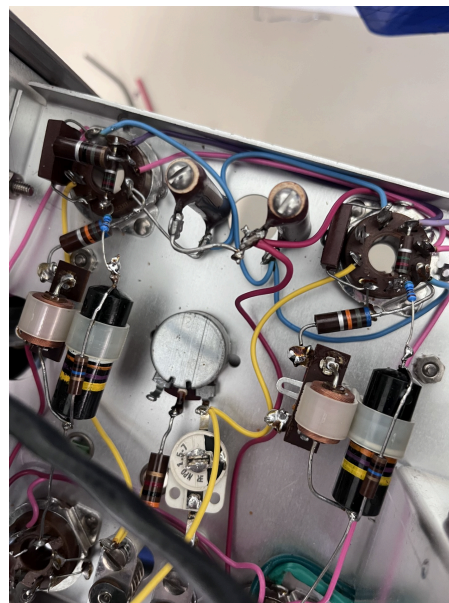
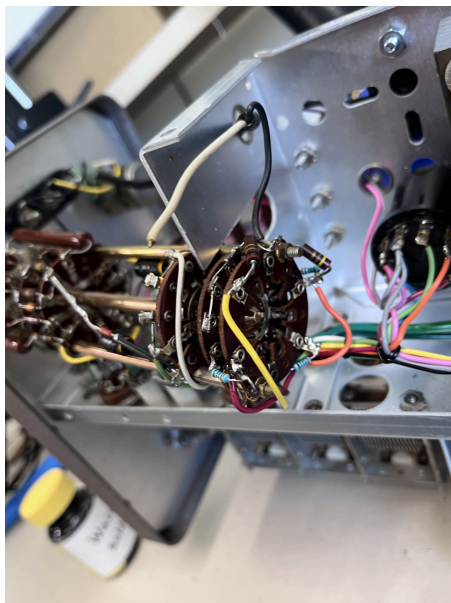
3/19/25: I was able to get one of the new capacitors soldered into place and had an idea of how to get the other one mounted today. Not much else has happened today.

3/21/25: Today my goal was to measure resistors and find out what was in and out of tolerance. Actually the carbon composition resistors tested within their specifications (Only 2 tested out of tolerance ranges with 4 others being very close) All 6 of these will be getting replaced with metal film resistors. Most of these ended up being on the attenuator output of the oscillator and the other two were mirror images in the amplifier. I found that mostly all of the resistors in the variable range switch to be within spec. With the largest deviation being .74%. I also think that

since all of these errors are higher than a calibration adjustment can be made to get oscillations back into spec. The resistors in the heart of the amplifier proved a little more difficult to check because everything was tied together. I had to strategically break the circuit into different sections in order to test. Looking up these components on Digikey it looks like they are all available to order as metal film, I will order those over spring break and have them to install for the next lab day. (Resistor list is shown on the last pages of this document)

4/4/25: I was lucky that spring break was between last lab day and today because it took 10 days for the resistors to show up. I got them replaced today. I ended up unbolting the switch deck in order to get to one of the 300 Ohm resistors. It was pretty difficult to get to. I also realised I'd leave the deck removed for next week because it will make the cleaning easier. The new resistors are the blue ones shown in the pictures below.

I will also take this time to note: **THE 56 OHM RESISTOR OFF OF V3 NEEDS RECONNECTED AND ALSO THE WHITE ATTENUATOR WIRE.** (This will be done after the cleaning) Update: 4/14/25: This is done



4/7/25: Today I worked on mounting capacitors again and got the 3 segment one soldered together and also the new 3D printed mount for the other capacitor of the power supply.

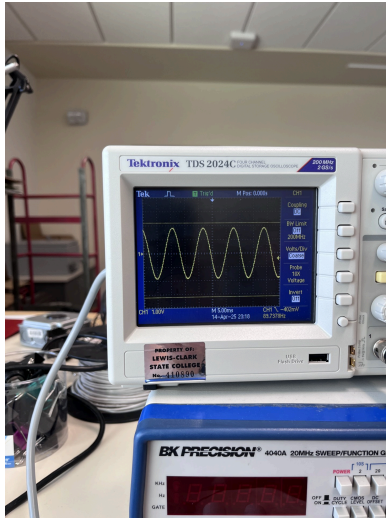
4/8/25: Today I worked on mounting that same capacitor because I had to remove a transformer and an inductor in order to get to the mounting bolts of the capacitor. I did this and it ended up looking good in the end.

4/9/25: Today I used the contact cleaner I bought yesterday to clean the rotary switch decks with some Q-tips. I have not gotten them as clean as I would like yet but they are getting there slowly but surely. I also used some oil on the drive shafts of the frequency adjustment knobs and given a few hours a large noticeable difference was able to be felt when turning the knobs. The big knob can now be turned as a “coarse adjustment” without feeling like nails on a chalkboard when turning.

4/11/25: Today I finished cleaning the rotary decks to the best of my ability. I will not be taking the switch apart because the manual says that it is replaced as an assembly and I think that would mean that it cannot be disassembled easily. I did take an alcohol soaked paper towel and wiped all of the dust off where it has settled over the years. (pictured below) I lastly took a spray can of air and used that to blow out the dust between the variable capacitor plates. I believe this cleaning of the rotary switch resistor decks and the capacitor plates will aid in a more stable frequency for the oscillator. This thing started out as being very clean for being almost 70 years old but it looks so much better now.



4/14/25: Today I finished connecting the capacitors in the power supply. After getting all bare wires (That I installed) shrink tubed I put the tubes back in, including the new rectifier tube and powered it up. I am very happy to say that a very large improvement was seen when powering it bad up. Below is a picture of the output sine wave with the oscillator set at 90 Hz as you can see the picture shows 89.73 Hz and the wave is much cleaner than It was before.



4/16/25: Today I performed the calibration procedure on the oscillator. I ran the procedure described in the manual. Here were a few things I noted:

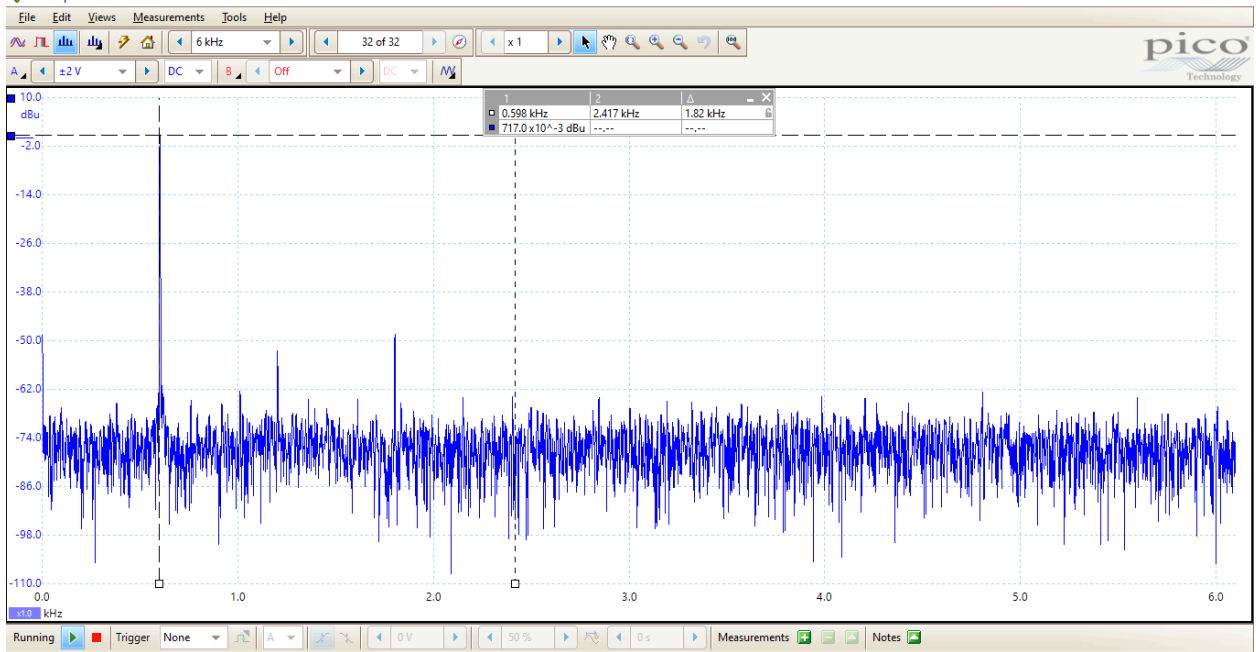
- When adjusting C6 for the “60” adjustment, the screwdriver used mattered because It would seem to add capacitance and change the frequency when I was watching it on the screen.
- I was again not able to capture 5 Hz or 600k Hz because my frequency standard did not go that far into ranges.
- I adjusted the “High end adjustment” on 500k Hz and while I was still not able to pinpoint the frequency matching the standard, It was much more discernible where it was at than before.

More testing will be done at a later date but as it stands it looks as if the oscillator is functioning better than it was before the calibration. (landing on the correct frequencies indicated by the dial.

I also measured ground resistance today and was able to measure about 52milliohms for the ground conductor to the internal chassis

4/18/25: Throughout this week I finished taking measurements after the calibration. Overall the oscillator is showing major signs of improvement. The furthest out any range

is the 25 setting on the 10k range (or 250kHz) It ended up being my greatest error with an error of 0.92% the maximum accuracy error for the oscillator is + or - 2%. (See supplemental tables of data findings.) Here is a spectrum analysis of 600 Hz showing a strong fundamental frequency and with harmonics at 1200 and 1800 Hz for the 2nd and 3rd harmonics.



4/23/25: As a wrap up I would like to say that this project ended up being a big success. I did not expect things to improve as much as they did with a light cleaning and some new components being swapped in. The oscillator functions very well for being an almost 70 year old piece of test equipment.

Resistor Initial Findings:

Resistor Number	Resistor Value (Manual)	Resistor Value (Bands)	Resistor Value (Actual)	Schematic Value	Measured Value	Difference	Percent Error
R1	2450 1%	2450 1%	2450	2.529E+03	2.532E+03	3.400E+00	0.13%
R1(A)	N/A	82 10%	82.4				
R2	24,500 1%	24,500 1%	24,500	25.260E+03	25.275E+03	15.000E+00	0.06%
R2(A)	N/A	820 10%	775				
R3	245,000 1%	245,000 1%	247,500	252.600E+03	252.888E+03	288.000E+00	0.11%

R3(A)	N/A	5600 10%	5,388				
R4	2.45M 1%	2.45M 1%	2.468M	2.528E+06	2.535E+06	6.700E+03	0.27%
R4(A)	N/A	68,000 10%	66,700				
R5	24.5M 1%	24.5M 1%	24.66M	25.790E+06	25.980E+06	190.000E+03	0.74%
R6				5.028E+03	5.036E+03	8.000E+00	0.16%
R7				50.520E+03	50.750E+03	230.000E+00	0.46%
R8				505.200E+03	507.500E+03	2.300E+03	0.46%
R9				5.056E+06	5.085E+06	29.000E+03	0.57%
R10				50.180E+06	50.400E+06	220.000E+03	0.44%
R19	10 M 10%	1.00E+07	1.006E+07				0.60%
R15	56 10%	56	56.5				0.89%
R25	56 10%	56	65.5				16.96%
R23	8.2M 10%	8.20E+06	7.93E+06				-3.29%
R24	8.2M 10%	8.20E+06	8.03E+06				-2.07%
R20	68,000 10%	68,000	66,100				-2.79%
R16	56 10%	56	56				0.00%
R21	68,000 10%	68,000	68,500				0.74%
R26	56 10%	56	61.4				9.64%
R22	10 M 10%	1.00E+07	1.00E+07				0.20%
R12	2700 10%	2700	2930				8.52%
R17	22,000 10%	22,000	20,860				-5.18%

R18	22,000 10%	22,000	21,030	-4.41%			
R33	300 5%	300	313.3	4.43%			
R34	300 5%	300	312.4	4.13%			
R37	200 5%	200	202.9	1.45%			
R38	200 5%	200	248.7	24.35%			
R42	220 10%	220	212.5	-3.41%			
R43	220 10%	220	237.4	7.91%			
R44	240 5%	240	238.5	-0.63%			
R45	240 5%	240	244.2	1.75%			