1965 Gibson GA-45RVT Saturn Amp

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Introduction

For my Physics 398 EMI project I decided to refurbish and modify a 1965 Gibson GA45-RVT Saturn guitar amplifier. This two-channel amp has bass and treble tone controls on each channel, has around a 45-50 watt output, two 10-inch CTS speakers, tremolo, and reverb. The reason for choosing this amplifier was because I had one at home that I had previously acquired for free from a relative. It was non-functional, and I thought that it would be great to get it working and would be a great project to learn about amplifiers. In addition, I already had the amp, so it would be less costly than building an amp from scratch because I only needed some replacement parts rather than all the parts.

The amp actually turned out to be in pretty good shape. Professor Steve Errede said he had worked on similar Gibson amps and that with some modifications I could turn this from an okay sounding amp into a great sounding amp. As it turned out, my Gibson Saturn turned out to be a great project amp that was a good foundation for modifications.

As previously mentioned, the amp didn't work, so the first stage of the project was to get the amp working. Steve suggested a number of modifications that I could make as desired to improve its sound after I got it working the way it was. As I worked on my amp, Steve taught me his philosophy of not making irreversible changes to the amp except when it was clearly the best option. I also learned about how he documents all changes and saves all the old parts in case one ever wants to return the amp to its original state. He also taught me about working carefully and doing work neatly inside the amp.

Repairs

The first thing I did was to clean the amp out a little. It wasn't too dirty, but I scraped some junk off the inside of the chassis and blew dust and dirt out with compressed air. It is a good idea to have a clean amp when working on it because it makes it easier to see what one is doing. It's also just good to have things clean. The first things that had to be replaced were the main high voltage capacitors, which were dried up. I had a couple options for replacing them and decided on two 20μF 475V multi-section (x4) can electrolytic capacitors. The reason I choose these was because there was limited space inside the chassis to properly mount normal capacitors and I could easily increase the capacitance with the electrolytic can capacitors, which would boost the bottom end of the amp. To mount the capacitors I had to punch holes in the chassis. This was one example of where I had to make a permanent change to the amp by punching holes in the chassis. It was the best way to install the capacitors and was how they were designed to be installed. Pictures of this are shown in the appendix. I also replaced other high voltage capacitors in the circuit.

The first modification I made before I tested the amp. This was to install a grounded power cord. Originally, it only had a two-prong power cord and a switch used to determine the polarity. This is unsafe because the musician could receive a dangerous shock if the amplifier was plugged in the wrong way. With the grounded power cord it can only be plugged in one way, so there is no need for the polarity switch, and the third prong of the cord serves as a ground reference.

When all the main high voltage capacitors were replaced and the grounded power cord installed, I plugged the amp in and tried it out. It worked, but not without its share of problems. Most notably, the two 6L6 power tubes needed to be replaced. One of them was microphonic, meaning that any vibrations to the tube caused an echoing sound to come out the amp. The pots were also scratchy. The presence switch made a loud pop when it was switched.

I replaced the two 6L6 power tubes with two Sovtek 5881's that Steve brought in. The pots were cleaned by squirting some cleaning fluid in them and rotating them to work the cleaning fluid throughout the pot. I also discovered that one of the 6EU7 tubes was bad and was responsible for some of the bad behavior of the amp including the popping heard with the use of the presence switch.

The foam inside the bag for the reverb tank deteriorated and made quite a mess so that was washed out and left to air dry. Other minor cleanup included scraping the oxide off the pins of the tubes so they would make better electrical contact.

The connector for the footswitch to turn on and off the reverb and tremolo was damaged when removed because apparently when it was previously worked on, excess solder had been left on the pins and the connector was jammed in. As a result it was too tight of a fit and didn't come out without the plastic on the connector breaking. Steve looked for an identical replacement but could not find one. However, he found a connector that would work. It was smaller than the original, so to make it work we cut a piece of metal and drilled a hole in it the proper size to mount the new connector. I drilled out the rivets of the previous connector and drilled holes in the metal plate to line up with the holes now in the chassis from where the rivets were. I used screws through these holes to attach the metal plate over the original connector's hole. A picture of this is shown in the appendix.

Modifications

Besides the grounded power cord, another modification I made was to install a 10k ohm pot to be able to control the amount of current flowing through the power tubes to prolong tube life and keep them from getting too hot. The line voltage has increased over the years, and so nowadays older amps are pushed harder than what they were originally designed for. I installed a 1-ohm resistor on each power tube. By doing so, the voltage can easily be measured across this resistor and by using Ohm's law, V=IR, with a resistance of 1 ohm, the voltage is equal to the current. The pot can then be adjusted to allow the desired current flow through the tubes.

The biggest modifications I made to the circuit dealt with some Twin-T circuits in the amp. A Twin-T circuit is a filter that has a drop-off in frequency response at the frequency given by $f = 1/(2\pi RC)$. Figures 1 and 2 show a sample Twin-T circuit and frequency response.

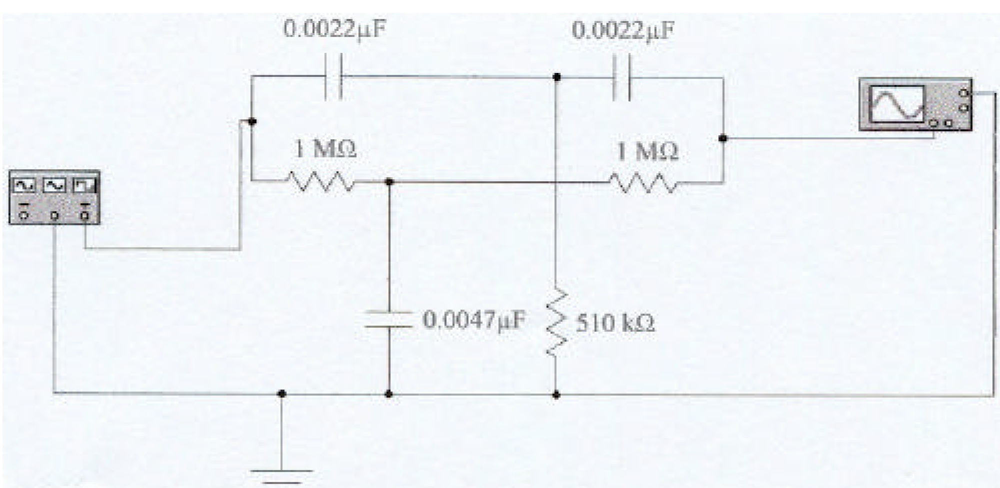

Figure 1 – Twin-T schematic

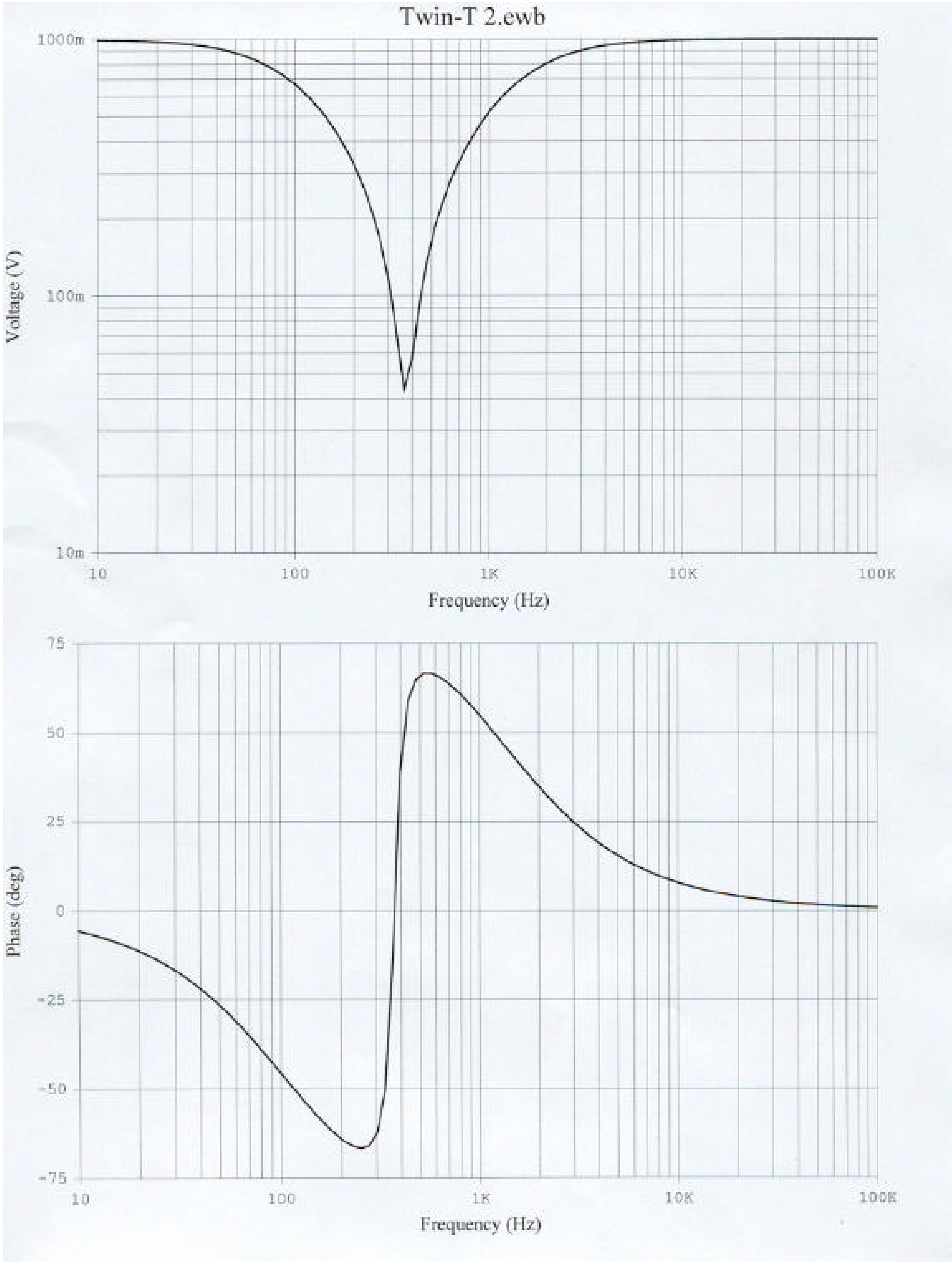

Figure 2 – Twin-T frequency response

There was a Twin-T circuit in the normal channel and one in the reverb channel that caused a large drop off in frequency response around 370Hz as well as caused weird phase shifting. There was one that was part of both channels that caused a huge drop off in frequency around 70Hz. These circuits make no sense in the amplifier and can easily be considered design flaws.

To confirm that these circuits agreed with theory I hooked a function generator to the input of the amp and observed the output on an oscilloscope. Combined with aural observations it was very clear that there was a large drop-off in frequency response at 70Hz. A noticeable frequency response drop-off was not very noticeable at 370 Hz. Perhaps the effect of the Twin-T circuit there was either more obscured or less drastic.

The next step was to model the part of the amp's circuitry containing two of these Twin-T circuits with a computer software program called *Electronics Workbench*. I was able to do a frequency analysis of the circuit without modifications as shown in figure 3 below. I then modified the circuit on the computer to remove the Twin-T circuit around 70Hz. The large drop-off in frequency around 70Hz disappeared as expected. This is shown in figure 4 below. I returned to the original circuit and removed the Twin-T circuit around 370Hz. The large drop-off in frequency around 370Hz also disappeared as expected. This is shown in figure 5 below. Then I removed both Twin-T circuits from the simulation and the frequency response leveled out as shown in figure 6 below.

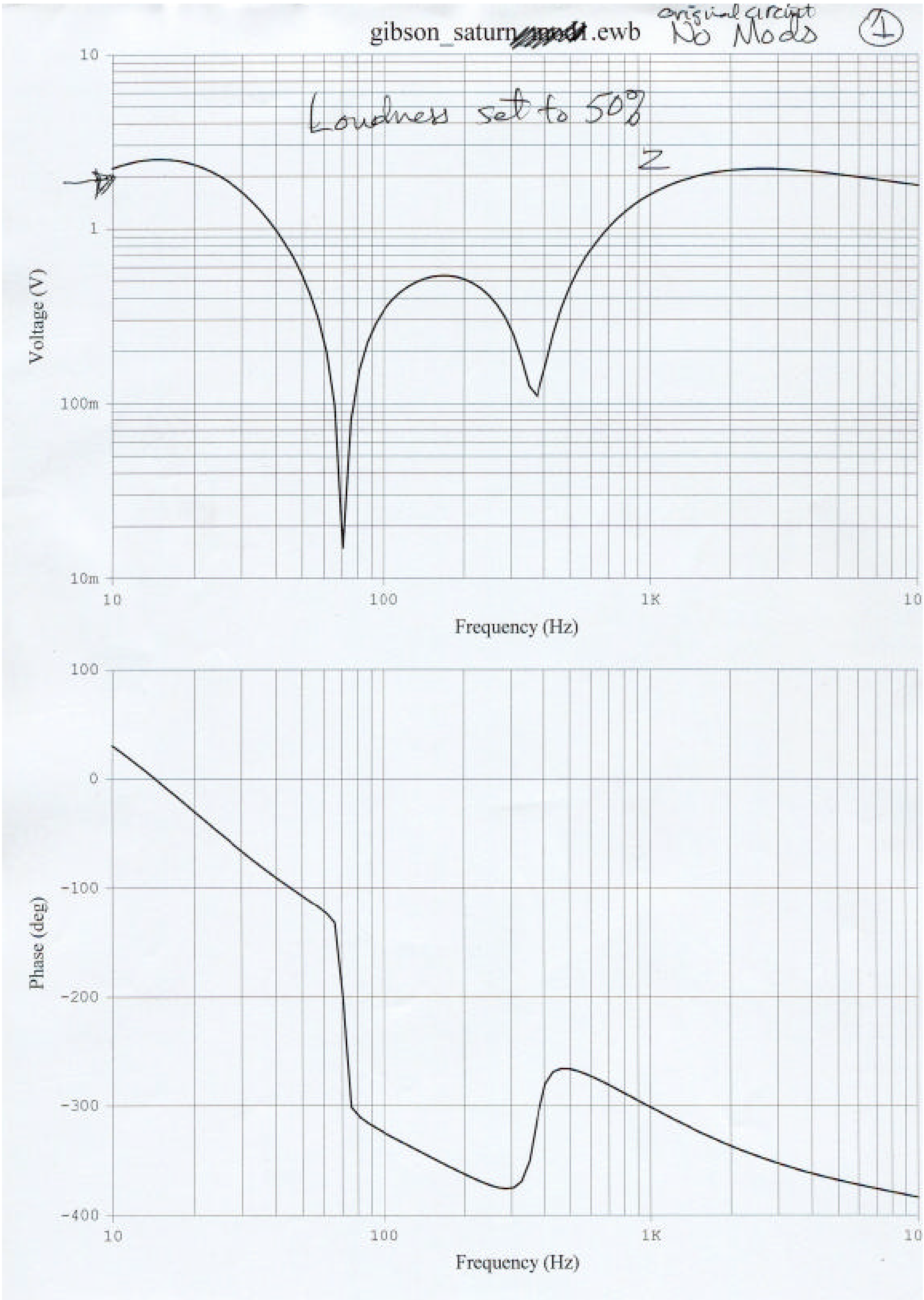

Figure 3 – circuit without modifications

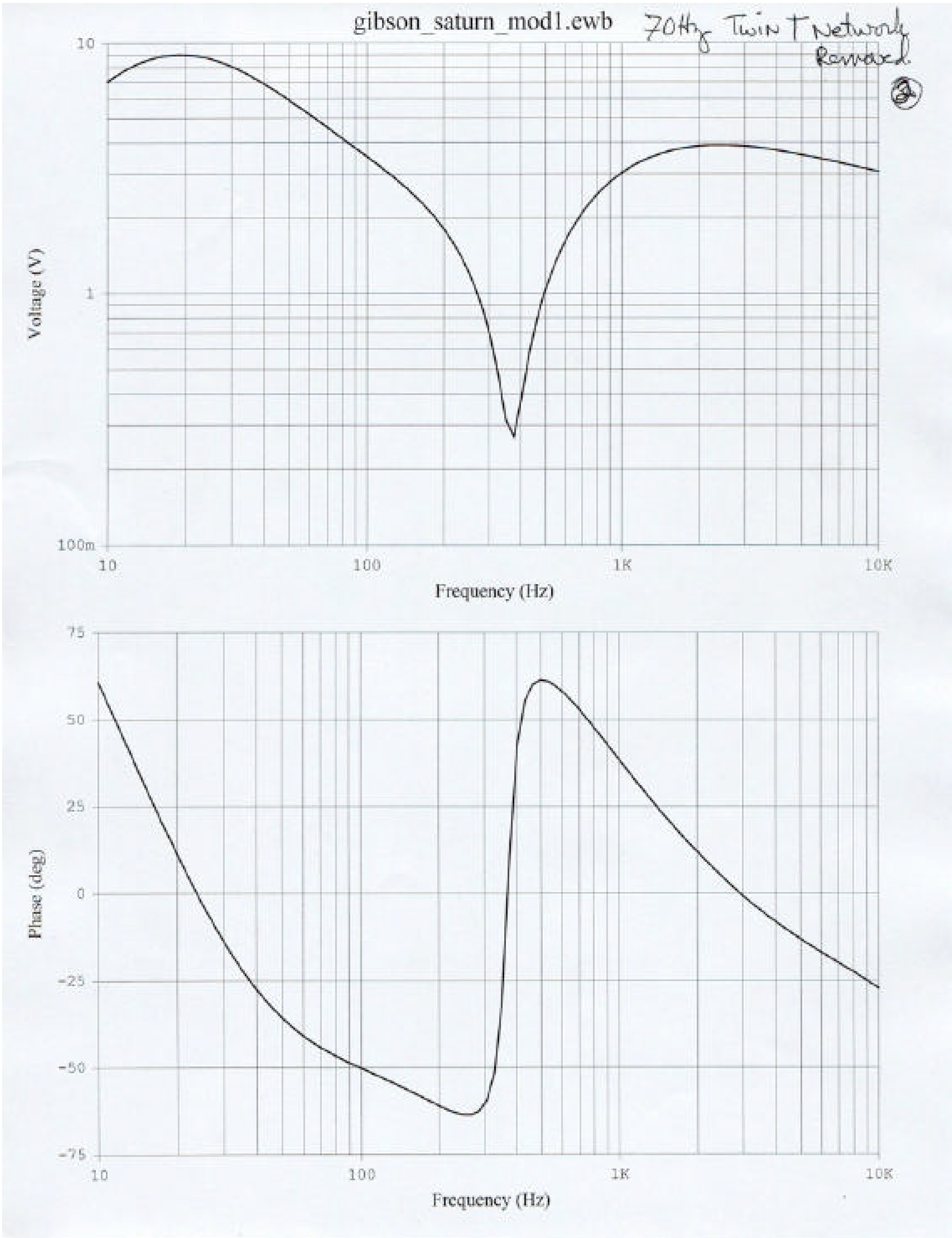

Figure 4 – circuit with Twin-T network around 70Hz removed

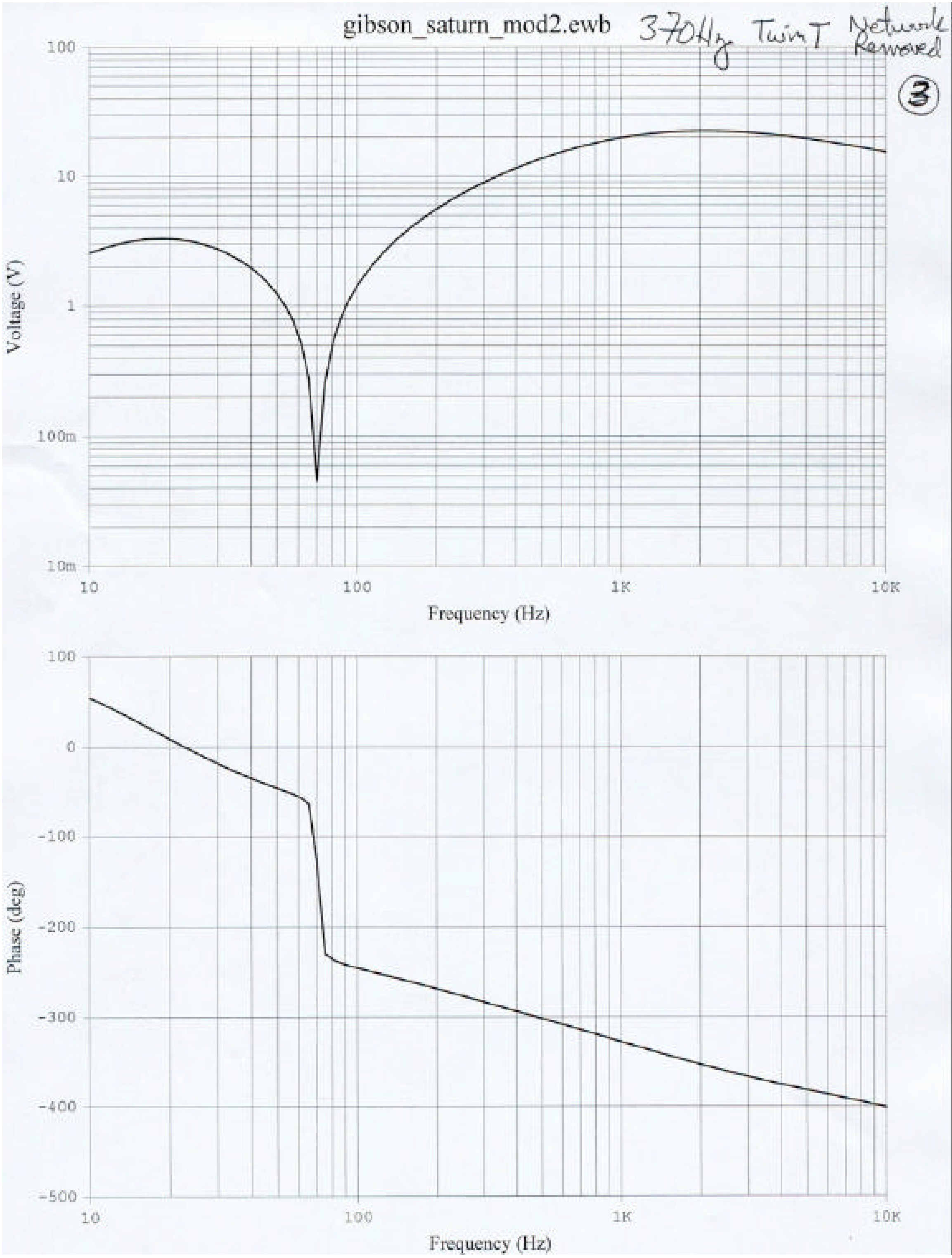

Figure 5 – circuit with Twin-T network around 370Hz removed

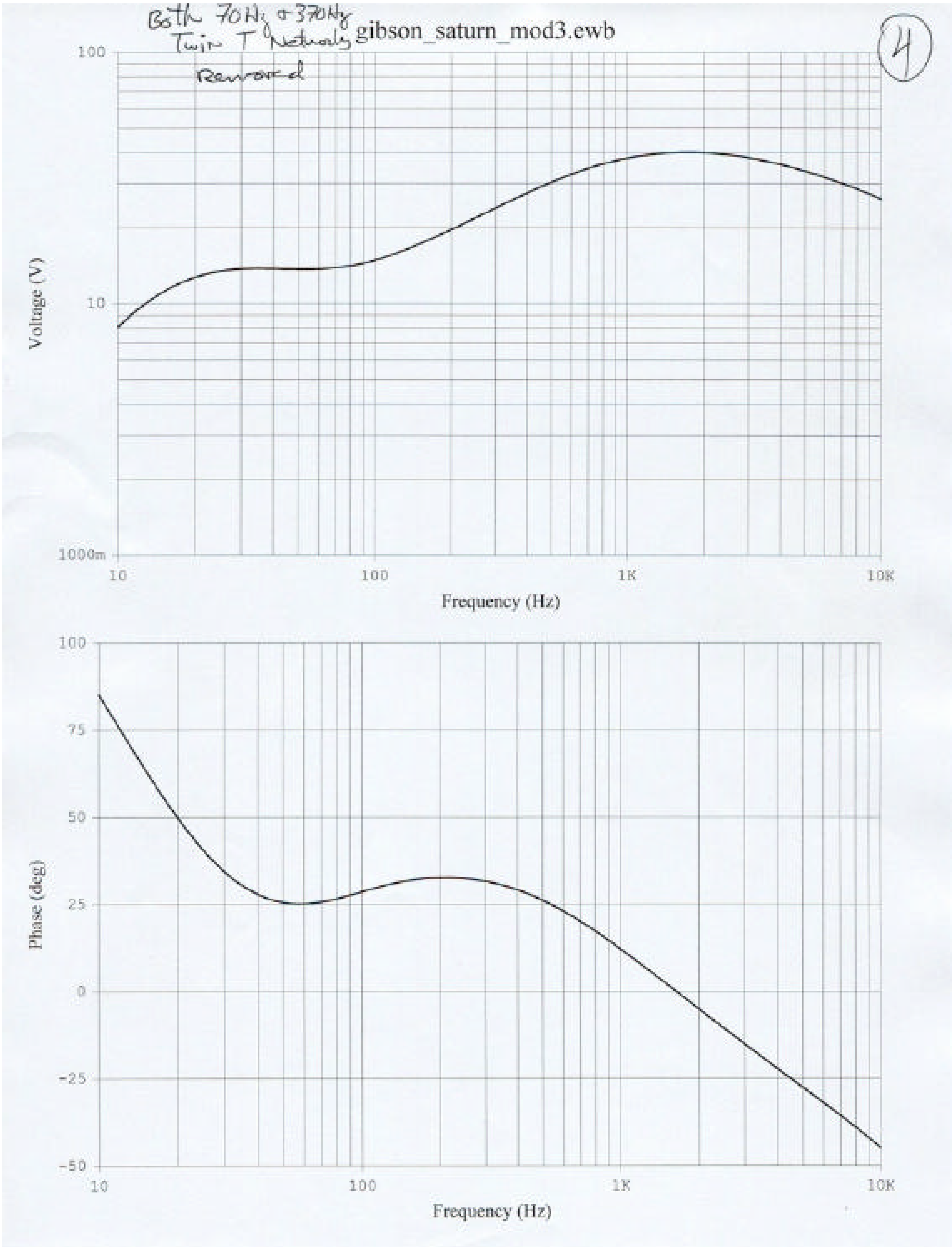

Figure 6 – circuit with Twin-T network around 70Hz and 370Hz removed

With all of this evidence I decided to remove these Twin-T circuits from the amp. By looking at the schematic and following components around in the chassis I was able to locate these circuits. Steve marked some numbers on the capacitors to designate which hole they came out of, as well as drew the circuits on paper in case the original circuits were to ever want to be restored. After this documentation of the circuits was completed, I removed them. I put in a 1M-ohm resistor in place of the 70Hz Twin-T circuit to keep the gain from become too large. There were also a couple extra capacitors to ground that I removed.

I also replaced four other capacitors with larger capacitance ones, 250µF, and two other capacitors with larger capacitance ones, 25µF, as suggested by Steve to further give the amp a solid bottom end. The appendix contains a schematic with all of the modifications indicated.

The final modification was to solder the speaker cable to the speaker jacks to provide a solid electrical connection. The connection with the clip that slid on had a lot of oxide and was not very tight which could have caused a flaky electrical connection.

Conclusion

With all of these modifications the amp sounded better. The most noticeable change to me was the presence of a bottom end. There simply was not the bass response with the Twin-T circuits that there is now without the extra circuitry. The amp is also quite a bit louder now. I'm happy with the way it sounds. It has a lot of reverb available which could create a great "surf" sound. Steve was right about it being an okay amp that could be a great amp. I learned a lot about amps by working on this project and would like to give a big thanks to Professor Steve Errede for all of his help.

Appendix

Figure 7 – Amp Chassis before removing Twin-T filters and replacing capacitors

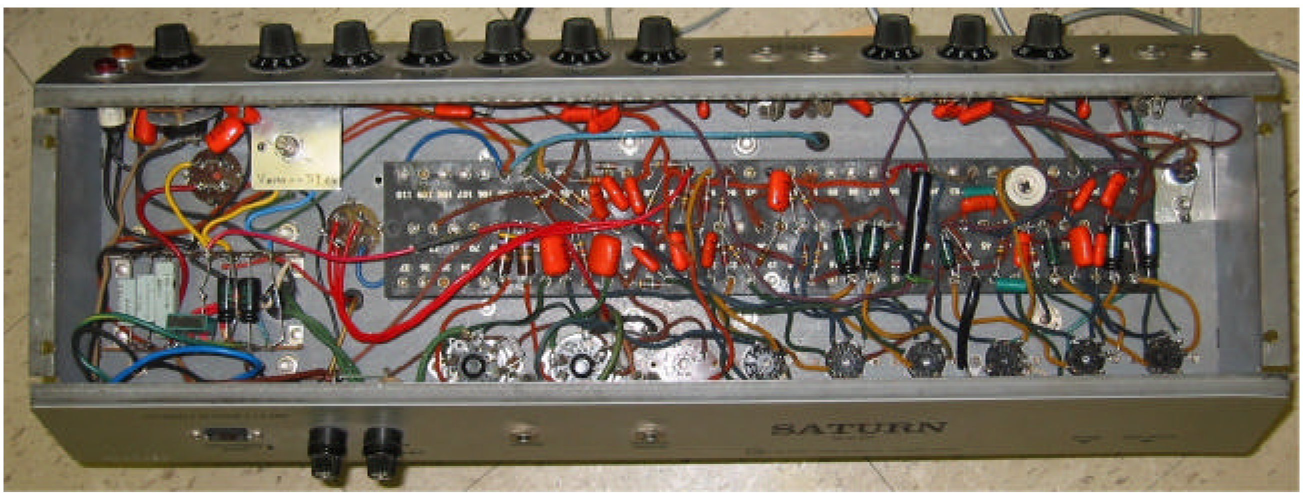

Figure 8 – Amp Chassis after removing Twin-T filters and replacing capacitors

Note in figures 7 and 8 where I installed the electrolytic can capacitors, which appear as brown circles on the left side of the pictures. On the far right is the metal plate I installed to hold the new footswitch connector. Note also the 10k ohm bias pot I installed on the left side as well as the gray 1-ohm resistors on the power tubes. By comparing figures 7 and 8, one can see all the extra circuitry that I removed due to the Twin-T filters, as well as the new higher valued capacitors I installed, which are black.

Figure 9 – Rear view of Gibson Saturn after completion of repairs and modifications

Note in figure 9 the electrolytic can capacitor I installed that is hanging down just to the right of the transformer on the left side of the amp. There is another one behind the transformer that cannot be seen in the picture.

Figure 10 – Front view of Gibson Saturn

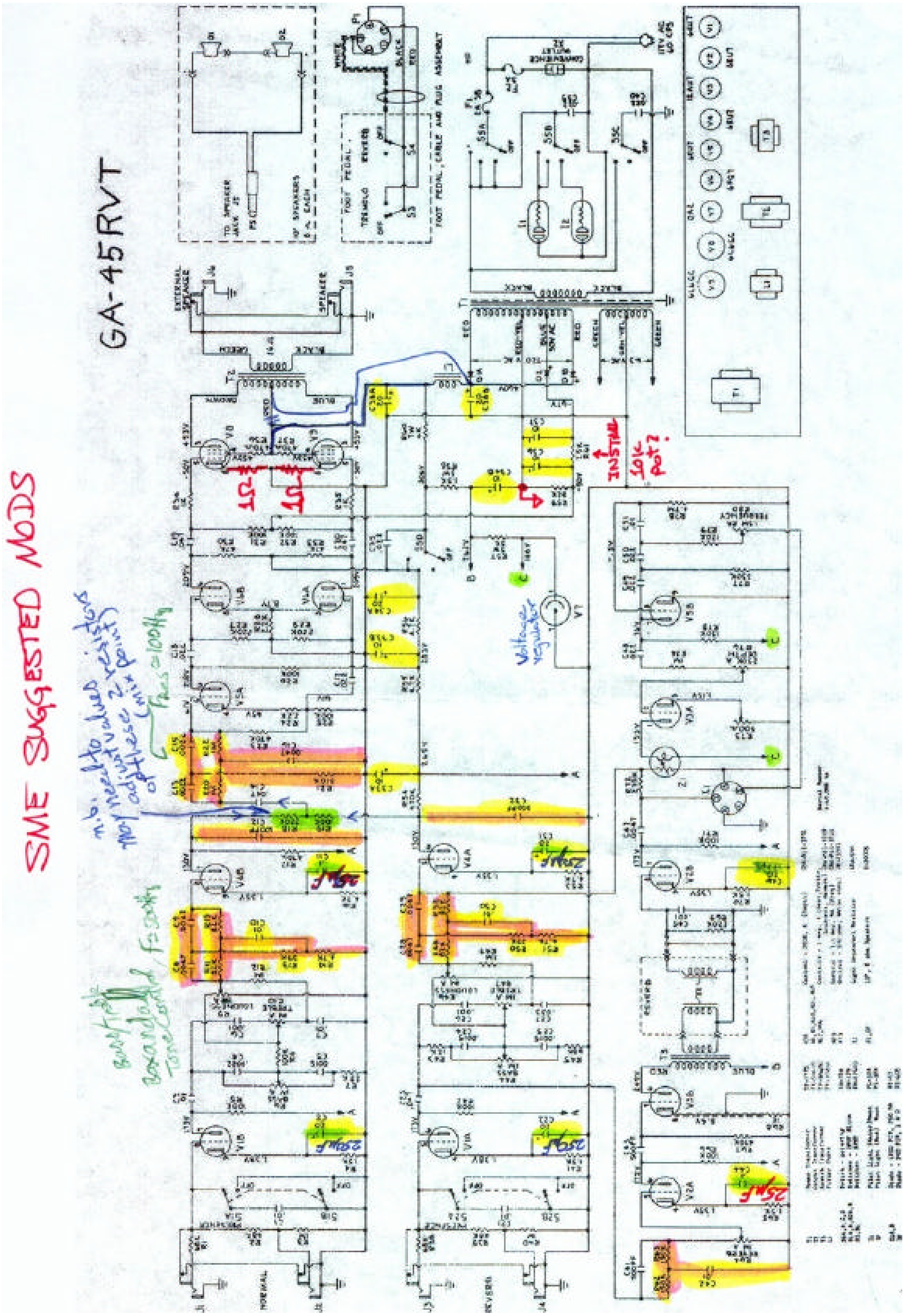

Figure 11 – Schematic of modifications