

Theremin met buizen

Rave On.

Tube-Type Theremin Construction Project. When RCA introduced their version of Lev Termen's invention they said it was as easy to play as humming. While the sound that can be produced by the Theremin may at times sound like singing or like a violin, the fact that you don't touch it to play it removes the tactile feedback normally found in the playing of a musical instrument. The musician stands motionless except the slight movement of the hands, closer to the pitch antenna and the notes glide up scale, further away and lower tones are produced. The closer the hand is to the volume antenna, the louder the sound. (this is the reverse of the original instrument, but I find it more intuitive to play this way.) Of the many Theremins that I have built the ones based on tubes sound the best and have the most sensitivity to the players' hand positions. The design presented here is the culmination of many years of experimentation.

The Theremin works on the principle that if you add two radio frequency signals together in a nonlinear amplifier the resulting output will be the sum and the difference of the input frequencies. In the Theremin we want the pitch antenna to control one frequency and the other one to be fixed. As the performers' hand adds capacitance to the tuned circuit controlling the variable frequency, the difference between the two becomes greater, resulting in an audible tone. The same "detuning" principle controls the volume.

The pitch antenna is connected to a parallel resonant circuit that forms a Hartly oscillator operating at about 700kHz. I chose the operating frequency to be high enough so that the half a pico-farad that the hand represents would provide a sufficiently large change in frequency and so alignment could be done using a AM radio. The fixed-frequency is provided by the Hartly oscillator around Va. The 150pf variable capacitor is mounted on the front panel and is the pitch control. It is adjusted so that when the performer is furthest away there is no audible tone but as the hand is brought forward the pitch rises. Another design criterion was that the Theremin be capable of playing very low notes. There is a tendency for the oscillators to lock onto one another when their frequencies are close. This causes the lowest note to be the one right before lock, usually a few hundred hertz. By using separate tubes for the two oscillators and by preventing any coupling between them the unit can produce tones down to tens of hertz. The RF signals are added and subtracted in the mixer tube V2b. By changing the value of the 1k resistor in the cathode line, the tube can be operated in a more nonlinear manner which along with the 10k resistor in the cathodes of V3 can alter the sound of the Theremin dramatically. The sum of the RF signals is not wanted and can cause background noises so it is bypassed to ground by the 100pf cap in V3a's grid. V3a and b are used as a voltage controlled amplifier in which the audio is applied to the grid of V3a and the control voltage to the grid of V3b. V4a is an oscillator just like the pitch ones except that the operating frequency is different. If the frequencies were close there would be heterodyning (sum and differencing) between these stages resulting in extra notes that would not follow the pitch antenna. The output of the volume oscillator is connected to a parallel resonant circuit that shunts the RF signal to ground when the oscillator frequency is above or below the circuits center frequency. When the two frequencies match, maximum voltage is presented to the voltage doubler consisting of the two diodes. As a result the grid of V3b is less negative and maximum output is achieved at the plate of V3a. The 150pf capacitor that controls the volume oscillator is mounted on the front panel and is adjusted for minimum volume when the performer is furthest away. As can be seen the circuit is Class-A, single-ended-triode throughout. The power supply is a straightforward, zener shunt-regulated type and any combination of components resulting in a regulated supply of approximately 250 volts DC would work as well.

As far as construction notes are concerned; keep the wires short, I used point-to-point wiring in my unit, and place the pitch and volume oscillators as far away from one another as possible. The volume antenna on my unit is a piece of PC board material about 8" by 4" mounted parallel to the floor and on the left-hand side of the Theremin. The pitch antenna is

mounted vertically and is a telescoping antenna from a portable radio. My Theremin was designed around inexpensive coils available from Antique Electronics (PC-70-OS \$3.00) and the other parts should be available in a well-stocked junk box. Silver Mica or NPO caps in the tuned circuit are a nice addition to keep the unit from drifting too much, but the player compensates for the drift anyway. Alignment of the unit is most easily done with an oscilloscope or a frequency counter or both, but the 700kHz range was chosen so that an AM radio could be used to align the Theremin. Start by removing V1 and V4, this will leave V2 as the only operating oscillator. Adjust the pitch capacitor on the front panel to the halfway position, tune the radio to about 700kHz and bring it near L2. Tune the radio and the pitch capacitor until a hiss is heard that can be moved along the radio dial with the pitch cap. Plug V1 in and repeat the above procedure using the slug in L1 and the radio dial. When you get both hisses on the radio adjust the slugs in L1 and L2 so that they occur at the same place on the radio dial. When they are close, a squeal will be heard on the radio and if you can't wait, you can start playing the instrument right now. Replace V4 and connect the Theremin to an amplifier line input. The squeal on the radio should now be coming out of the amp. Adjust the volume capacitor on the front panel to the halfway position and alternately adjust L3 and L4 until a point can be found where minimum volume occurs.

There are a few areas to explore now that you have a working model. First how about a second fixed-pitch oscillator for a second note say a fifth up. Second you might try wiring another parallel resonant circuit in series with the pitch and volume antenna wires to increase the sensitivity even further.

All of the Theremin articles I have read caution the would-be Thereminist to practice for quite a while before attempting the "premier performance" and after hearing Clara Rockmore (The Art of the Theremin, Delos CD) I totally agree. I use the instrument with a bunch of synthesizers and stick to more experimental kinds of music. Some really great, although non-traditional, Theremin sounds can be obtained by running the output through signal processors such as frequency dividers, Echo, and distortion units.

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