

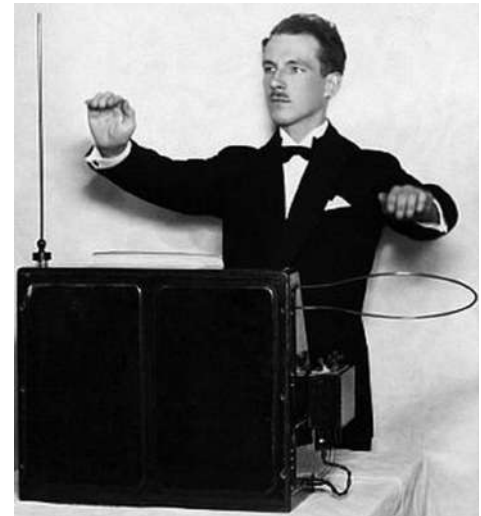
Theremin – the Inventor and the Instrument

Wing Sun

The theremin is an electronic musical instrument controlled by the performer's two hands without any physical contact with the instrument. The instrument was invented in 1920 by a young Russian physicist Lev Sergeyevich Termen (known in the West as Léon Theremin). The theremin is the first mass produced electronic musical instrument.

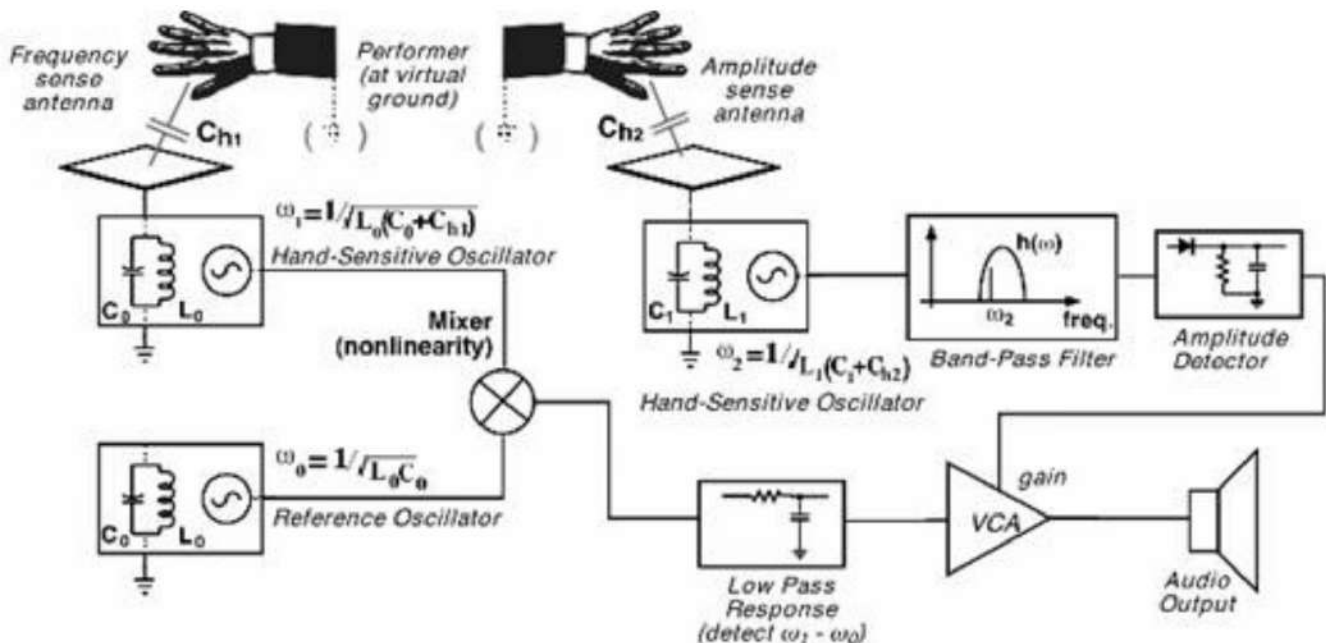
How Does the Theremin Work?

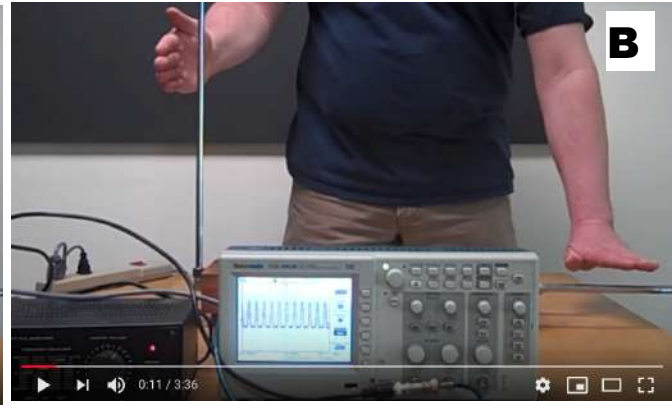
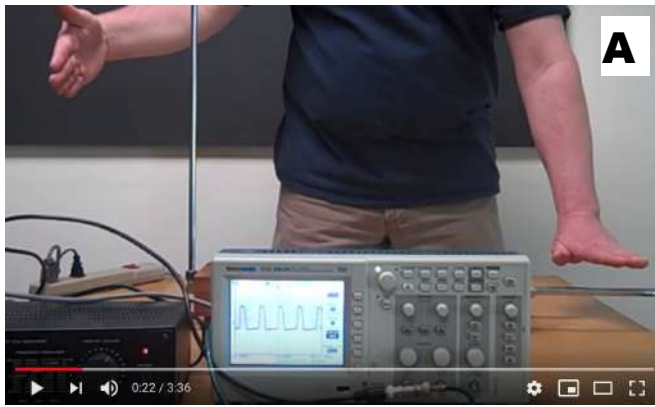
The proximity of the right hand is detected by use of a radio-frequency (RF) antenna that determines the pitch (frequency) of the sound. The proximity of the left hand is detected by use of another RF antenna that determines the volume of the sound. The electric signals from the theremin are amplified and sent to a speaker.



Pitch is changed by the capacitance of the right hand, or whatever goes close to the pitch antenna. The right hand circuitry has two very high frequency oscillators (around 350 KHz). One of them is fixed, and the other is varied by the hand capacitance; it's the difference between the two frequencies (the beating frequency) that decides the pitch. Even a 0.05% change in the variable oscillator can be substantial at audio frequency - enough to give a range of about five octaves. Thus, the position of the right hand is sensed by the change of capacitance it introduces in the pitch antenna, this change controls the frequency of the variable pitch oscillator.

The left hand circuitry works in a similar way via the volume antenna. The proximity of the left hand derives a control voltage that adjusts the gain of the voltage controlled amplifier and hence the amplitude of the output. The resulting sine wave output is processed to give more complex waveforms which provide a choice of tone colors in addition to the pure sine wave tone.





The audio signals on an oscilloscope can be seen at <https://www.youtube.com/watch?v=KREB87iahcU> to demonstrate how the theremin operates. Panel A shows a lower pitch as the right hand is farther away from the pitch antenna. Panel B shows a higher pitch as the right hand is closer to the pitch antenna. Panel C shows a decrease in volume as the right hand is farther away from the volume antenna. This action for controlling the volume can be reversed, as many thereminists would prefer.

Léon Theremin

Born in St. Petersburg in 1896, Leon showed a promising talent for physics at an early age. In high school, he had his very own laboratory in his home, experimenting with electricity, magnetic fields, and circuits. Throughout his college years, he was mentored by the famous Soviet scientist Abram Fedorovich Ioffe. Leon studied particles and their correspondence with their surroundings in mid-air. By 1920 he experimented with oscillations in the Institute of Physical Engineering in St. Petersburg. He also worked on the first ever burglar alarm which would go off if a man approached it. It was one of the first research that introduced proximity sensor technology and its practical use. Around 1920, Leon constructed his famed instrument. The original invention was called the “aetherphon,” because it sounded like it produced the sounds directly from the air, but later he changed the name to “Theremin.”

Leon started to promote his magnificent instrument in New York City, USA, during Christmas in 1927. He quickly gained fame and journalists flocked to interview him about the instrument. In 1929, Leon got a patent issued and ordered the RCA to mass produce the instrument. Unfortunately, the timing was bad as the stock market crashed in October during the 1929 Great Depression. This did not stop Leon to work extensively on his experiments and curiosities. He invented the first ever security system with automatized doors at Sing Sing Prison in Ossining, New York. In 1936, he married an African-American ballet dancer, Lavina Willaims and they stayed together despite the public opinion.

In 1938, Theremin returned to the Soviet Union. Allegedly, he was forced by Soviet agents to work at “Sharashka,” which was a secret Soviet laboratory forcing condemned scientists to do researches and experiments. There, Leon managed to construct the world’s first listening device, simply called “The Thing.” It was deviously used for spying on the British, US, and French embassies in Moscow.

The Thing

The Thing was a passive covert listening device planted in the study of the US Ambassador in Moscow, hidden inside a wooden carving of the Great Seal of the United States. It is called a passive device as it does not have its own power source. On 4 August 1945, the Vladimir Lenin All-Union Pioneer organization presented a hand-carved replica of the Great Seal of the United States to US Ambassador Averell Harriman, as a gesture of friendship to the USSR's World War II ally. It hung in the library at the Residency Spaso House. Unknown to the Americans however, the carving contained an RF bug of a novel design, in that it didn't have its own power source and was not connected via wires. Instead, the device was illuminated by a strong radio signal from the outside, which powered and activated it. It gave the bug a virtually unlimited life and provided the Soviets with the best possible intelligence.

In 1951, a British radio operator was monitoring Russian air force radio traffic, when he suddenly picked up the voice of the British Air Attaché loud and clear, but a survey of the embassy did not reveal any hidden microphones. A similar thing happened to an American interceptor in 1952, when he overheard a conversation that appeared to come from the ambassador's residency at Spaso House. After a search by the Department of State, the bug was finally discovered by means of a so-called crystal-video receiver, whilst the Russians were actively illuminating the bug. The bug was finally discovered by the US State Department in 1952, three ambassadors later, during the tenure of Amb. George F. Kennan.

The Thing is a so-called resonant cavity microphone, consisting of a resonant cavity and an antenna. The resonant cavity has a membrane that acts like a microphone to pick up the audio signal. The resonant frequency of the cavity is over a 1 GHz (within the microwave range). A remote transmitter (TX) sends an illumination signal (an electromagnetic wave) to the resonant cavity. The electromagnetic signal is modulated by the sound signal, if present. The antenna re-emits a modulated signal back to a remote receiver (RX). After demodulation, the sound signal can be recovered.

Similar concept and technologies have been used in modern day devices, for example, the radio frequency identification (RFID) and the transponders such as the E-ZPass.

