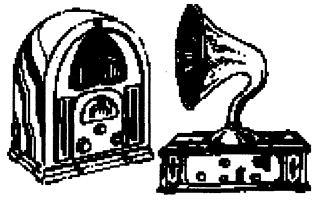
Vintage Radio

by PETER LANKSHEAR



Vintage electronic music

Electronic equipment in various forms is an essential part of today's popular music, especially for amplification, note generation and tone modification. For half a century and more, there have been power amplifiers, electric stringed instruments, electronic organs, and more recently synthesisers have added their distinctive character. As with many branches of electronics, pioneering efforts created some interesting equipment.

The death about five years ago of Leon Theremin at the age of 97 was a reminder of the achievements of a remarkable but relatively little known pioneer. A brilliant engineer, and also a capable musician, he is best known for his invention of the electronic musical instrument that took his name.

He was born as Lev Sergeyevich Termen in the beautiful Northern Russian city of St Petersburg (called Leningrad following the revolution, but with Lenin falling from favour, it again has its original name) where he was educated in physics, astronomy and most importantly, music — especially the cello. After moving to America, when presumably he anglicised his name, he developed some electronic instruments, including the 'Rhythmicon' which generated different rhythms, and which seems to have been a forerunner of the drum rhythm facility of some electronic organs.

Leon Theremin combined his musical and electronic talents to set about developing a completely new musical instrument, that did not depend on banging, scraping, strumming, plucking or blowing! Perhaps not surprisingly, he based it on existing electronic tone generation technology. Named after himself, the instrument was demonstrated first in Carnegie Hall in 1929, where it was well received.

As can be seen from Fig.1, it somewhat resembles a conductor's podium sprouting two antennas — one a straight rod, the other bent in a loop. As is usual with electronic instruments, a loudspeaker completes the equipment.

Electrical tone generation is as old as telephony. According to some accounts, it was Alexander Graham Bell's practised ear recognising harmonics in the waveform generated by a plucked steel strip placed close to an electromagnet that led to his inventing the telephone. Of course, alternating current generators could produce sinewave voltages in the audio range, but it was not until the availability of amplification that variable electrical tone generation could become a practical reality.

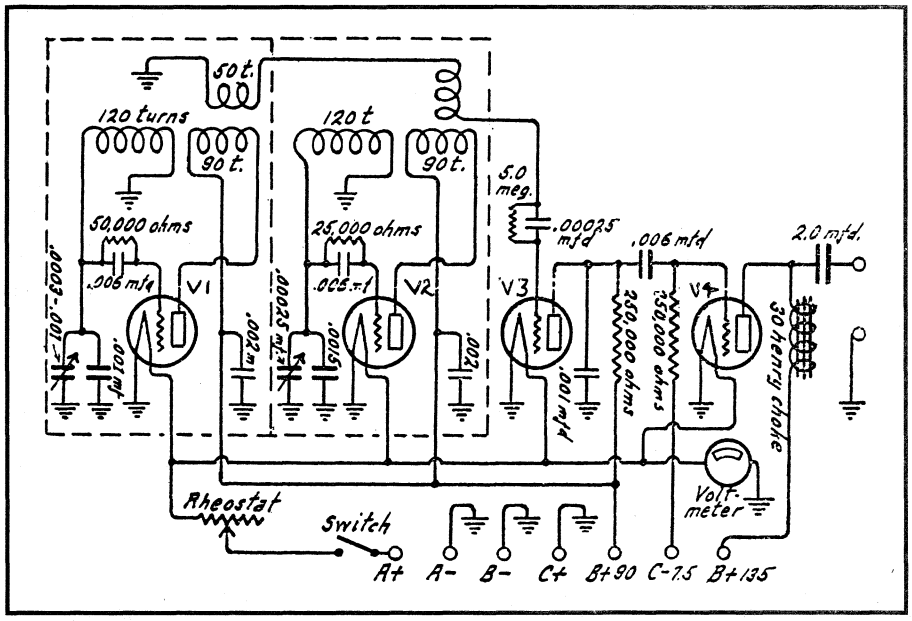


Fig.1: The Beat Frequency Oscillator, an early type of variable audio frequency generator. The signals from variable frequency RF oscillator V1 and its fixed frequency partner V2, were combined in the grid leak detector V3 and the audible difference beat, or heterodyne, was amplified by output valve V4.

Single note generation by a steel tuning fork and sustaining amplifier was an early single frequency method, but with the technology existing, a variable frequency was hard to produce. Simply to scale up the coil and capacitor combination used for RF oscillators was impractical. For example, a tuned circuit resonant at 1kHz with a 0.001mfd (1nF) tuning capacitor requires an inductance of about 25 henries, which for sufficient accuracy should be air cored.

Clearly a different approach was required, and during the 1920's the 'Beat Frequency Oscillator' or BFO appeared, a typical circuit being shown in Fig.2. The basic operation is quite simple, and is derived from heterodyne reception, first suggested about 1904.

Referring to Fig.2, there are two RF

oscillators. V2 operates as a fixed frequency oscillator, while V1 is variable, tuned by a 300 - 1000pF tuning capacitor. Samples from both tuned circuits are combined in a square law detector V3, and the difference frequency or 'beat' appearing at its output is amplified by the fourth valve.

With the two oscillators operating at the same frequency, there is no beat, but as the difference increases, so an audio beat with increasing frequency is generated. By suitably proportioning the tuning range of the variable oscillator, any desired part of the spectrum can be covered. Many of the early audio signal generators used this BFO principle.

Theremin understandably based the operation of his instrument on the beat frequency oscillator, but to produce music by rotating a dial was obviously impractical.

No physical contact

The Theremin is unique in that there is no physical contact with the operator. Instead it is 'played' by varying the positions of the hands in relation to the aerials. Anyone who has operated an unshielded regenerative receiver in an oscillating condition, whereby the received signal is continuously heterodyned, will know that, although the results are not very musical, it is possible to vary the tuning capacitance and with it the frequency of the audible note by putting a hand near to the detector coil. Theremin used a refined version of this for his oscillator control.

Approaching the rod antenna with the right hand raises the pitch of the rather eerie sound, which is not unlike that produced by the old party trick of a carpenter's saw played with a violin bow. Vibrato effects can be added by rapidly wriggling the fingers of the right hand, although in the recordings that I have heard, this effect is not much in evidence.

Volume is controlled by the proximity of the left hand to the looped antenna. The closer the loop is approached, the greater the volume. A later modification in some instances was the more conventional resistive volume control.

Three oscillators

The schematic of Fig.3 shows the circuit of the original Theremin, taken from Rider's *Perpetual Trouble Shooter* Volume 1, page 505. This book confirms that the RCA Theremin would have been produced in 1929/30, and

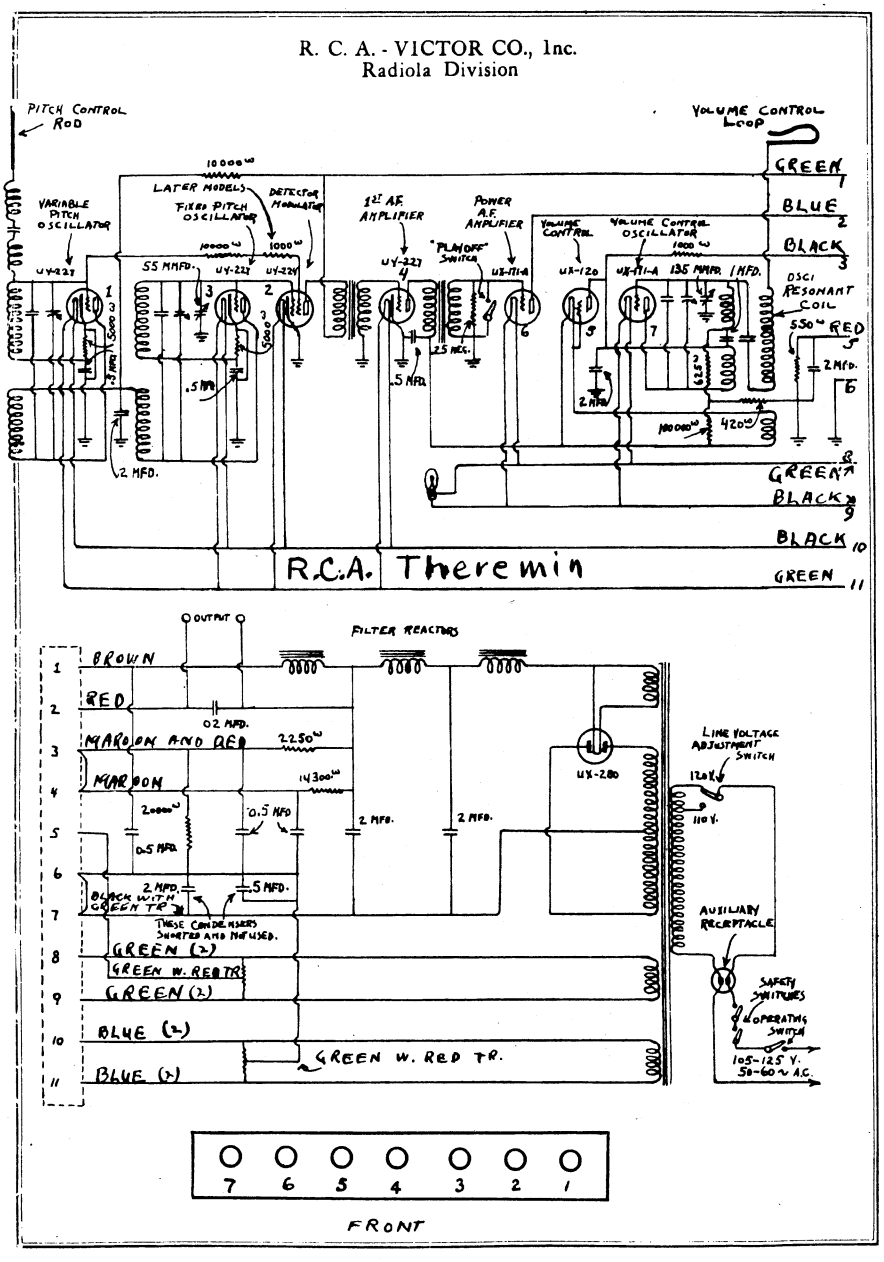
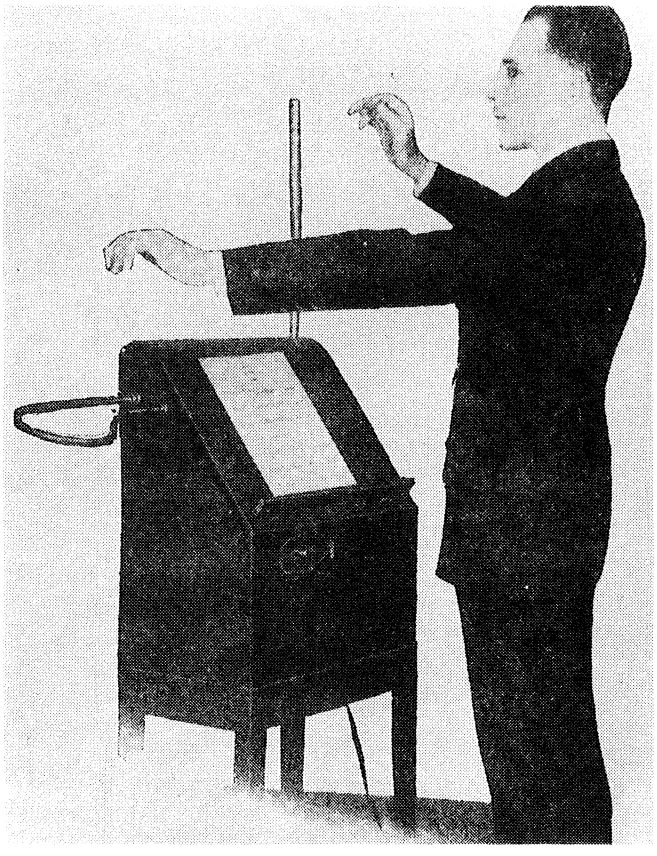


Fig.3: RCA built the Theremins after Atwater Kent declined, and as was their standard practice at the time, the power supply was constructed on a separate chassis.

provides a detailed idea of the Theremin's operation which was quite sophisticated for its time. It uses a 224 screened grid valve which was not available until early 1929, and had production of the Theremin been later than 1930, the circuit would have appeared in a later edition of Rider. The heterodyned outputs of a pair of oscillators, one controllable in pitch by the proximity of an operator's hand to an aerial rod, provides the melody. A third oscillator, controlled by the other hand, regulates the volume.

V3 is a simple fixed-frequency cathode biased 227 triode oscillator, operating in a clear channel somewhere near 500kHz with a tuned grid and an anode feedback winding. V1 is another 227 oscillator, but is coupled to the short vertical tuned aerial called the 'pitch control rod'. The grid of V3 is connected in parallel with the control grid of V2, a 224 tetrode, while the grid of V1 is connected to the outer screen grid of V2, which operates as a sort of bi-grid valve, forming the mixer or detector stage.

In the quiescent state the two oscillators operate at the same frequency and produce no audio beat. (One fortunate characteristic of beat frequency oscillators in this sort of application is that as the frequencies of oscillation



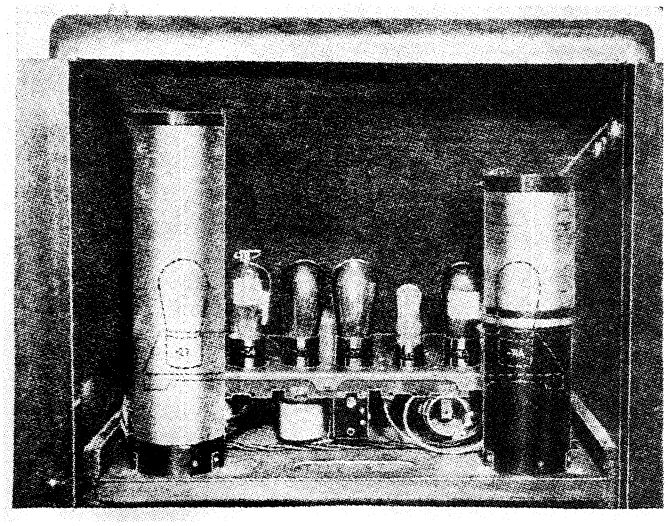


Fig.2 (left): Leon Theremin playing his instrument, which somewhat resembles a podium. The volume loop and pitch antenna can be clearly seen.

Fig.4 (above): The rear of the Theremin with the cover removed. At the left, the large coil is the pitch aerial loading coil, while the coil at the right belongs to the volume control oscillator. This photo and that of Fig.2 have been copied from 'Radio News' for March 1930.

approach each other, there is a strong tendency for them to lock, producing a zero beat). A hand in the proximity of the rod alters capacitance and with it the variable oscillator frequency. The closer the approach, the more the frequency is changed and the pitch of the beat frequency raised.

The audio frequency beat appears at the anode of V2, which is transformer coupled to a 227 triode audio amplifier stage (V4) — whose anode voltage is supplied in series with V5, a diode connected thoriated tungsten filament type 120 valve. From the anode of the first AF amplifier, the audio signal is transformer coupled to a 171A power triode (V6), which provides the drive to the external loudspeaker of the Theremin.

Novel volume control

The technology used in controlling volume is ingenious, and was quite sophisticated 65 years ago. Valve V7 is another 171A power triode, connected as an oscillator. A small positive voltage grid bias of about a volt is provided by a voltage divider formed by the 100kΩ and 420Ω resistors. The oscillator coil has two additional windings, one of which lights the 3.0 volt filament of the type 120 valve (V5). A fourth winding and the 'loop' aerial form a high-Q resonant aerial system. In the resonant condition, the loop and its coil absorb most of the oscillator's energy, and the filament of V5 receives minimal voltage. Consequent-ly, V5 will not permit any anode current to flow, and the first AF amplifier V4, whose anode is fed from V5, is inoperative with no signal reaching the grid of the AF power amplifier.

When the aerial system is detuned by the proximity of the of the musician's left hand, less energy is absorbed by the loop, and instead becomes available for the filament of the control valve, V5. This makes V5 conductive, permitting current to flow in the first AF amplifier

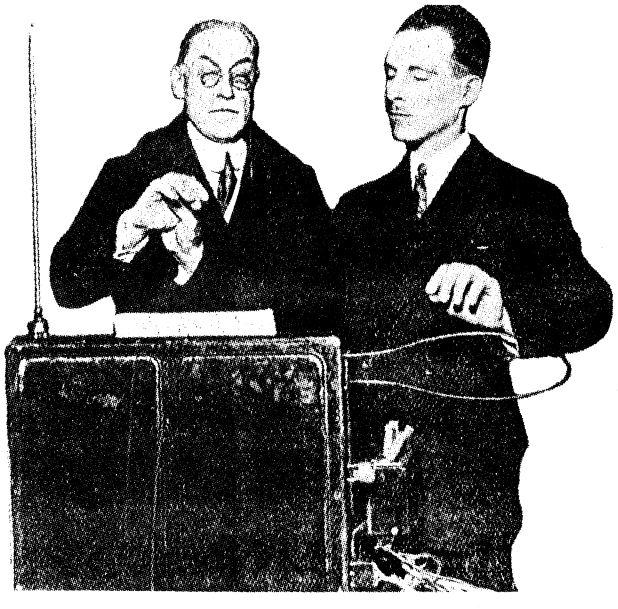


Fig.5: Another photo, taken from the Australian magazine 'Radio' for May 15, 1928, showing Theremin demonstrating his instrument to Sir Robert Hadfield in London. The article in which it appears is headed 'Russian Inventor Plays Tunes with Howling Valves'.

and the musical tone to reach the power amplifier. The success of this novel method of volume control would have been dependent on an unusual characteristic of the thoriated tungsten filament of the 120 type valve. Thoriated tungsten filaments provide an extended relationship between filament current and emission, and would provide a smoother control than would an oxide coated filament.

To ensure that the Theremin remains completely silent when not required, there is a 'Play Off' switch to earth the control grid of the power amplifier stage.

As was common RCA practice at the time, the power supply was made a separate unit and the circuit shows safety switches to disconnect power if access covers are opened. The power supply unit appears to be remarkably similar to that used for the all triode Radiola 60 superhet, which by late 1929 was becoming obsolete.

Initially Theremin offered manufacturing rights of his instrument to Arthur Atwater Kent, but the latter considered that it was insufficiently developed and with limited potential demand, and the project was instead taken up by RCA. One suspects that ultimately, Atwater Kent's opinion was correct.

The Theremin is too restricted in performance to ever be more than a novelty instrument, although some music was written for it and it is occasionally heard in broadcasts. Plans for later versions have been published from time to time, but there was not much further development. Major limitations are that chords are not possible, and the rather bland tonal quality cannot be readily varied. In any case with no keyboard, only gliding note changes are possible.

Theremin developed other instruments, one being an electronic cello. There was also a small keyboard organ, but within a short while much more versatile electronic instruments like the Hammond organ were to follow — and of course, these were a considerable success. The Theremin's importance is that it pioneered the use of electronics in musical instruments, which has changed the whole structure of popular music.

Shortly before World War II Theremin returned to Russia, but was banished to Siberia — all too easy during Stalin's reign of terror — for his 'anti Russian writings'. However eventually he must have been considered to have improved his ways sufficiently, because he was released to work on military electronic equipment. Later he was to be 'pardoned' after receiving the Stalin Prize for his work.

He worked for a time as a KGB scientist, but was forced to leave Russia in 1967 after receiving too much publicity in the West. By then he would have been in his mid 70s, and unlikely to be a threat to the Soviet Union.

Footnote

And now something quite different. Provision for personalised car number plates can produce some clever combinations that can be often be humorous. American hams frequently use their callsigns. However, a New Zealand acquaintance of mine has a very novel set of plates that only a fellow vintage radio enthusiast would appreciate. His car is registered as UX201A. ❖