# THE HISTORY OF ELECTRO-MUSICAL INSTRUMENTS IN RUSSIA IN THE FIRST HALF OF THE TWENTIETH CENTURY

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**ABSTRACT**

Analysis the history of electro-musical instruments in Russia in the first half of twentieth century shows that this period characterized by great interest of acousticians and audio engineers to develop a new generation of this type of instruments. This paper describes the most successful early Russian electro-musical instruments.

## 1. ELECTRO-MUSICAL INSTRUMENTS INVENTED BY LEV THEREMIN

### 1.1 Thereminvox

Created in 1919 by a Russian inventor, researcher and musician Lev Theremin (1896-1993), *Thereminvox* became one of the first electro-musical instruments in the world.

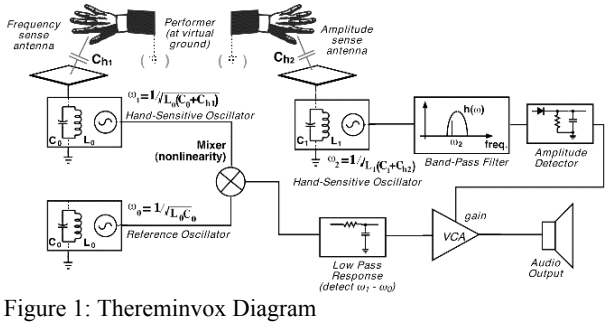


Figure 1: Thereminvox Diagram

The principal part of the *Thereminvox* is made up of two high frequency oscillators (heterodynes) tuning at the same frequency range. While the frequency of one oscillator remains unchanged that of the other can be modified by changing the condenser capacity. The condenser is connected to a vertical metal antenna. If you move your hand towards this antenna the capacity of the condenser including into $L_0C_0$-circuit is changed due to the variation of the electromagnetic field properties around it and, accordingly, the frequency of the alternating electromagnetic field is also changed. Then the signals produced by both oscillators are summated, the difference tones located in an audible frequency range are filtered, amplified and sent to a loudspeaker. Hand movements within 40-50 cm distance of the antenna makes possible to change the pitch within the range of 3 to 4 octaves. The other horizontal antenna shaped as a loop was also included into the supplementary high frequency oscillator circuit. When a performer's hand move in its proximity, amplitude modulation signal is generated. Next it is sent to a filter, an amplitude detector and finally to an amplifier and a loudspeaker. This circuit is used to change sound volume.

*Theremivox* excited great interest of the public. This was due not only to the instrument's timbre singularity - its sound thanks to its expressiveness can indeed be compared to the human voice - but also due to the unusual method of generation sound. It was the first instrument ever which didn't need to be touched by its user. Later Lev Theremin created a keyboard modification of the *Thereminvox*, but it was less successful. Another Russian inventor, L. Korolev greatly contributed to instrument improvement by introducing a device visualizing the spatial fingerboard (this was a scale depicting pitch height according hand position); a device for expansion set of timbres and tuning system stabilization (irrespective of air humidity) and other. The combination of these new modifications made it much easier for musicians to play the instrument.

### 1.2 Terpsitone

*Terpsitone* (after Terpsichore- the Greek muse of dance) was manufactured in 1930 when Theremin stayed in the USA; the other name for this instrument is *Theremin ethereal-music-dance platform*. The instrument operation principle is very similar to that of *Thereminvox*, as it is based on creating beats produced by the interaction of two high frequency oscillators.

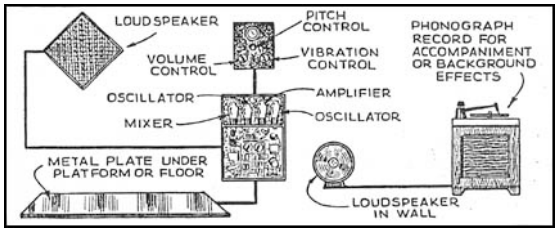


Figure 2: Terpsitone Diagram

The sounds produced by the dancer's movements can be supplemented, if needed, by the specially selected for this purpose background music. Another peculiarity of the invention is the presence of the automatic integration of sound and color. The "Visual sound quality detector" is a lamp panel, where lamps have different colors. In time with the sounds generated by the dancer's movements lamps on the board flash on; moreover, each tone has a corresponding color. The sounds generated by the dancer are displayed by lights flashing on and off simultaneously. "Visual sound quality detector" is made up of two oscillators, of which one makes constant sound pitch (that can regulated) and the other is variable; its performance is affected by a dancer's movements on the dance floor and by changing of the capacitance of the oscillator circuit under the metal plate. The signal is then applied to the mixer. Then it is sent to the sound amplifier and the lamp panel. On the control panel, which is located on top of the instrument, there are volume and timbre controls as well as a vibrator control that is responsible for the lamp panel of visual detector.

The second modification of the instrument was produced in 1966-1967, while Theremin was working in Moscow Conservatoire. And yet another copy was manufactured for Lydia Kavina, the inventor's niece, who is the best-known

contemporary *Thereminvox* player, in 1970's and this copy has belonged to her ever since.

### 1.3 Rhythmikon

*Rhythmikon* was created by Lev Theremin in 1931 in response to the request from an US composer Henry Cowell. The project was also supported by Charles Ives. *Rhythmikon* became the first rhythm-machine. It was designed to create any rhythmic patterns the player might wish. An original mechanism of this instrument included sources of light and rotating perforated disks.

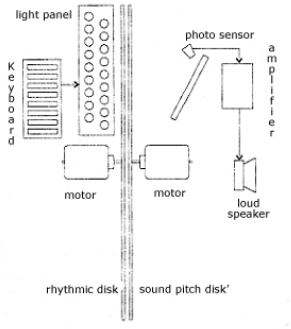


Figure 3: Rhythmikon Diagram

*Rhythmikon* has keys resembling those on a piano, disk speed controls (for *'sound pitch disk'* and *'rhythmic disk'*) and a photo sensor with an amplifier which shape the produced rhythm. *The sound pitch disk* is a metal black disk 20 inches in diameter, which has holes (half inch in diameter each) located on a circle. The disk is rotated by an electromotor, whose speed can be changed from 700 to 150 r/m (rotations per minute) by a variable resistor. Alongside its rim the disk has 96 holes; the closer to the centre the number of holes is 90, 84, 78 etc. The total number of these circles with holes is 16. *The rhythmic disk* is, too, a metal black disk 20 inches in diameter. A separate electromotor rotates it at a lesser speed than that of the sound pitch disk. The hole's circle closest to the rim has only 16 holes. Each smaller circle has one hole fewer than an adjacent bigger circle. The number of the circles is also 16. The light panel contains light sources so that it can generate rhythmic patterns and has two vertical rows of light indicators. The first of these rows, which is closer to the rhythmic disk has nine light indicators, while the other row has eight which are positioned parallel to the first row and at a small distance from it.

The light penetrating through both disks is intercepted by the photo sensor, which is positioned on one side of both disks opposite the light indicators. *The sound pitch disk'*s main function is audio signal generation. The signal's frequency is determined by the disk's rotating speed and the number of holes that let through the light. *The rhythmic disk*'s function is shaping the intended rhythmic patterns. Its typical speed is around 60-70 r/m. The two disks are positioned on the pivot in such a way that the round holes in both disks let the light through onto the photo sensor each time a hole in each disk is into alignment with both the light source and the sensor. This way the holes of the rhythmic disk serve as a mask or a window for the light penetrating through the sound pitch disk. When the hole in the slower rhythmic disk is into alignment with both the light source and the sensor, the window is opened and, at the same time, a number of the sound pitch disk holes come in turn into alignment with it.

The process can be easily used in a modification with a greater number of lamps. The total number of manufactured *Rhythmikons* was three. The first one was in Stanford University, but it stopped functioning. Another is also in the US in Smithsonian institute. The third one was produced by Lev Theremin in 1960's and is kept in Moscow Conservatoire.

## 2. KEYBOARD ELECTRO-MUSICAL INSTRUMENTS

In 1920-1930's the first fingerboard and keyboard monophonic electro-musical instruments were developed in Russia; they were: *Sonar* by N. Ananyev (1931), *Violena* by V. Gurov and V. Volynkin (1927), then *Equodine* by A. Volodin (1932), *Emiritone* by A. Rimski-Korsakov etc [1].

### 2.1 Equodine

*Equodine* seems to be one of the most successful inventions in the field of engineering research of that time. The instrument was designed to be played in concert as a solo instrument with piano accompaniment, but it could also be used as part of instrumental ensembles. The instrument possessed a wide frequency range (six octaves and a half), allowed to produce a great variety of tones (over 330 combination) and was capable of imitating almost any symphony orchestra instrument.

A number of *Equodine* modifications were created in 1950's: *Equodine* V-9, V-10 and V-11. For instance, V-10 was a stereophonic multi-timbral instrument which allowed the user to set the timbre for each voice as well as merging two voices. Each voice allowed for 128 combinations of timbres. The size of the instrument was 700x750x500 mm, its watt consumptions was 80 Watt.

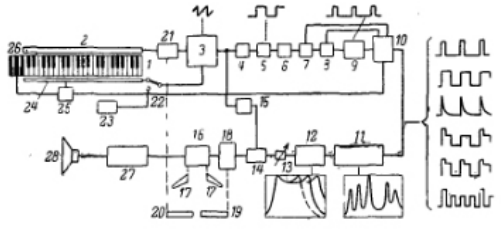

Figure 4: Equodine Diagram

The instrument operation principle is following [2]. Keyboard (1) through a multiple rheostat (2) set an operating voltage to oscillator (3) which range is 3.33 octaves (according a frequency of repetition of impulses). This range is expanded with the aid of division octave devices (4-7), which are switched during a performance by a key range selector. Last division devices (7-8-9) are included to the circuit of the spectral converter (10) which is shaped seven different waveform of signals. Then filters (11-12) are configures different variants of spectra envelopes with specified formant features related to different musical instruments. After the amplitude limiter (13) a signal passed to the additional band pass filter (14). Timbre modifications are involved due to a commutation in blocks (10, 11, 12) and (9, 14). For an additional timbre nuances a special band pass filter is located (16), its characteristics are varied with a selector levers (17) during a music performance. The dynamics controller (18) is switched by a right pedal. Left pedal (20) is located for switching the block of smooth pitch transition (21). The chain is ended by an amplifier (27), included into acoustics system (28). Main oscillator (3) have two inputs – main and additional – for a generation of frequency modulation

with the aid of a commutator (22). A performer could choose a automatic vibration by a generator (23), or to make finger vibration with an underneath a keyboard electromechanical transformer (23). Underneath a keyboard is located a starter device (25) for a shaping an amplitude envelope, which modes are set by a keyboard manipulator (26), that allowed to create a mode of attenuation sounds with different roll-off and time.
*Equodine* was awarded the Grand Gold Medal at the World exhibition held in Brussels in 1958.

### 2.1 Neoviolena and Emiritone

Another instrument which was created in 1920's – 1930's which it is important to mention is the invention of an engineer V. Gurov that was named *Neoviolena*.
Contemporaries described *Neoviolena* as 'producing a pleasant and 'juicy' sound that resembled different symphony orchestra instruments (in accordance with its settings) and possessed a wide range of sounding shades and timbres.'
The instrument was first manufactured in 1927. Direct generation of sound frequency signal was used as its operating principle. When pressed by a finger a steel string came in contact with the metal fingerboard, which was incorporated into the circuit of a frequency oscillator; at the same time the metal plate on the fingerboard responded to the intensity of the pressure and sent the signal to the volume control positioned under the fingerboard.
In 1932 a group of researchers: A. Rimski-Korsakov, A. Ivanov et al. invented a melodic instrument which worked along the same principles as *Neoviolena*. The new instrument, named *Emiritone*, which became quite popular as an instrument played in concert. The name originated from the initial letters of 'electro-musical instrument', the initial letters of the surnames of the two inventors and the word 'tone'. It has a keyboard of the same type as the piano. The instrument is based on an electronic valve oscillator which produces the electric current of a sawtooth waveform. The form of the electric current determines the future combination of the sound timbres, whose total number equals 540. *Emiritone* is provided with a keyboard-fingerboard interface, which incorporates non-even-tempered ultrachromatic fingerboard, a special chromatic keyboard and a double pedal responsible for nuances.

## 3. PHOTO-OPTICAL METHODS FOR SOUND SYNTHESIS

Another area which exited particular interest of acoustics researchers and musicians in 1920's and 1930's was using photo-optical methods for sound synthesis. An extraordinary technique of graphic method of sound recording was developed at the beginning of 1930's simultaneously in Moscow and Leningrad. The technique was successfully applied to creating experimental animation films. Sets of synthesised timbres drawn on a film were made in the State Music Science Research Centre (1921-1926); these could be played with the help of a special "vibroexponator".

### 3.1 Variophone

In order to synthesise artificial sound tracks using the technique of 'paper sound' an electric optical synthesiser was made. It used not graphic samples but samples cut out from cardboard, so-called 'crests', whose combs could be combined to produce chords etc. The first wooden modification, named *Variophone* appeared in 1931. Yevgueny Sholpo was the author of the invention. The instrument allowed for unrestricted alternation of sound pitch, obtaining glissando, vibrato, shades of sounding, changing the sound volume and producing polyphonic chords (up to 12 simultaneous tones). The instrument works on rotating disks with cut out indentation shaped as a sound wave which from time to time block the ray of light that forms the outline of the sound track. The shooting was produced with a special transmission, passing the rotation of electric motor, which let the mechanism, stretching a photographic film, move. *Variophone* was used for creating sound track for a considerable number of films. Another unique peculiarity of this instrument was the possibility of modeling subtle rhythmic nuances.

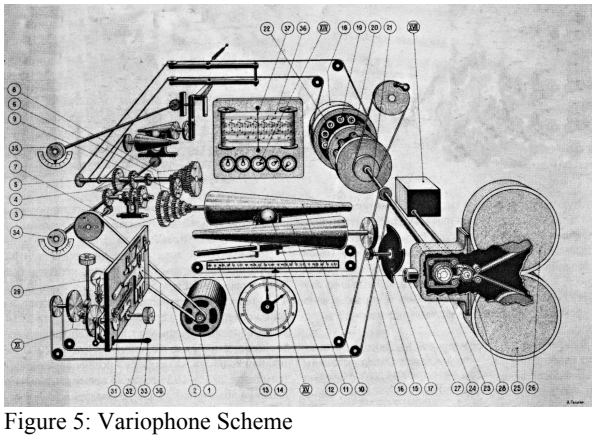

Figure 5: Variophone Scheme

## 4. "ANS" SOUND SYNTHESISER

ANS sound synthesiser was created by Yevgueny Moorzin and became world famous due to its being used in E. Artemyev's sound tracks written for Andrey Tarkovsky's films. The *ANS* acronym stands for the initials of the great Russian composer Alexandre Skryabin, who was the first person in Russia to suggest the concept of merging light, colour and music in a new art form. *ANS* was the first Russian-made sound synthesiser that applied the unique method of optical synthesis.
*ANS* was built in 1950's though its concept was shaped back in 1937. The synthesiser is a device which combines three processes: composing, recording and playback of recorded music. Making music on *ANS* a composer had to inscribe the desired sounds on glass, which was covered in nontransparent nondrying paint, by taking the paint off certain spots on the glass with chisels. The glass serves as a kind of instrument score. The recorded sequences of sound codes can be immediately played back on the device, hearded and corrected. All possible voices, noises and polyphony maybe inscribed at a one glass. Sounds are synthesized in the score as a combination of single-frequency tones with the chosen principles of its amplitude transformation. For this purpose composer can applies 720 controlled oscillators in the range of more then 10 octaves. The principal scale of *ANS* is denied into 72 intervals. Working with precision recorder, applying cross-cutting technique it is possible to get a division of an octave into 144 intervals, and even into 216 intervals.
The principal characteristics of *"ANS"* are following:

- Optical oscillation of pure tones
- Photoelectric pickup of useful signals
- Magnetic long-term memory
- Chanel amplifiers – vacuum tubes

- Operating circuits – semiconducting radio electronics
- Electric power supply of blocks – semiconducting, stabilized
- Range of spectrums within temperation of 72 degrees – from 20 to 20000 Hz (10 octaves)
- Range of spectrums within temperation of 72 degrees for 6 mordent octaves and within 144 degrees temperation for 6 upper octaves – from 40 to 10000 Hz
- Number of controlled one-half registers – 20
- Number of controlling registration channels – 10
- Degree of accuracy of formants compounding – 5 dots per octave
- Degree of accuracy of envelop compounding – 22 dots per allotment
- Dynamic range into useful signals spectra in the score – 48 and 24 dB
- Maximum sharpness of percussion sounds attack – 1 ms
- Maximum speed of score moving – 24 ms/sec
- Minimum amount of operative memory – 20 sec
- Principal resolution characteristics of scanning point at the score – 0,8 mm
- Power supply – 50 Hz, 220 V

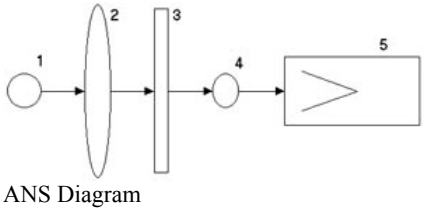

Figure 6: ANS Diagram

Light from the optical source (1) pass into a rotating disc of photooptical generator (2). It's intensity modulated by the sound tracks. Mask (3), which is located between a disc (2) and a reading photo element (4), pass the rays only from useful tracks. After photoelement is used cinema reinforcement chain (5). Sound synthesis methods of E. Murzin carrying on traditions of graphic sound synthesis (presented in the works of E. Sholpo), became an attempt of modulation the shape of sounds oscillations or its spectra-temporary characteristics.

E.Murzin continued experiments both in the field of graphic sound and of spectra synthesis, which were conducted at 1920-30 years in Soviet Union. In consequence of this continuity *"ANS"* integrated in the sphere of Russian electro-musical instruments and arouse a great interest among the composers and musicians. Nowadays "*ANS"* is kept in the Mikhail Glinka museum in Moscow.

## 5. CONCLUSIONS

Unfortunately, most of the archives belonging to the first electro-musical instrument inventors haven't been preserved and there are not enough recordings of the way those instruments sounded or footages from the concerts where they were played. Both the names of the inventors and their unique inventions are almost unknown not only to an average amateur, but even to professional musicians. The powerful figure of Lev Theremin, is much better known.

Yet the continuity of the foundation principles in the field of electro-musical instrument designing laid by its pioneers back in 1920-30's, the promotion and development of these ideas in a new generation of electro-musical instruments made in Russia in the second half of the 20-th century meant that the unique peculiarities of Russian electrical musical instruments had been preserved.

## 6. REFERENCES

[1] Aldoshina, Irina; Pritts R. Musical acoustics. SPb., *Composer*, 2006.

[2] Volodin A. Electro-musical instruments. Moscow, *Energy,* 1970