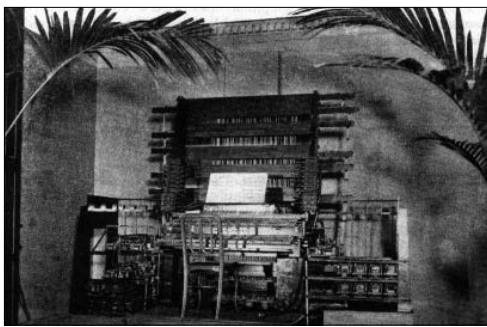


## Electronic Instruments and Computer Technologies in Contemporary Orchestra

“I dream of instruments obedient to my thought and which with their contribution of a whole new world of unsuspected sounds, will lend themselves to the exigencies of my inner rhythm” – these words of Edgar Varèse (New York, 1917) very clearly predicted the coming turn to main tendencies of XX and XXI centuries. From the very beginning of emergence of analogue and computer technologies in the sphere of music two main courses are being observed:

- The application of processes, which derived from sciences or are aided by computer technologies, for the organization of musical structure;
- Timbral synthesis of sound, its transformation, search for the new spectrum of sound. It is worth noting, that the use of electronic and computer technologies in music was first of all implied by the need of new structural or sound possibilities. This principle is also very relevant in the context of contemporary orchestra.



Picture 1. Dynamophone or Telharmonium



Picture 2. Theremin

At the beginning, let me present a quick overview of technical development, which enabled the invention and usage of new, electronic instruments. Most important novelty in 18th century was the advanced exploitation of electricity. In the broadest sense, the first electrified musical instrument was so called “Denis d’or” (“Golden Dionysus”), invented and constructed ca. 1753 by the Czech theologian Václav Prokop Diviš (1698–1765), who was also known as European inventor of lightning rod (independently of Benjamin Franklin). The mechanical part of the instrument was well advanced, with the ability to imitate the sounds of various instruments (including harpsichord, lute etc.), however its highlight was the ability to charge the iron strings with electricity. It was first aesthetically important implementation of principles, which were characteristic for future electronic instruments: the search for diverse sound and exploitation of scientific developments.

In United States in 1897 Thaddeus Cahill patented an instrument called Telharmonium or Dynamophone (Picture 1), which was the first music synthesizer. It was based on the same technology later used in Hammond organ construction. Using tone-wheels to generate musical sounds as electrical signals, it was capable of producing notes and overtones at any dynamic level. This method was based on so called additive synthesis, conceptually related to the work done by french mathematician Joseph Fourier. There were three version of the instruments constructed, ranging from the weight of 7 to 200 tons. The intention of the inventor was to use the instrument commercially by broadcasting the concerts to the large public spaces like stations or shopping centers, or via recently invented telephone. Due to lack of interest however Cahill’s enterprise was bankrupt by 1914.

Based on the Russian government sponsored research in proximity sensors, Russian physicist Lev Sergeivich Termen (later know as Léon Theremin in the West) invented Theremin (Picture 2), which may be considered the first significant electronic music instrument. Player’s hands are moved in front of two metal antennae, one of which controls pitch, the other – volume. Theremin quickly gained a wide acclaim, was presented internationally, from bolshevik leader Lenin to Radio Corpora-

tion America (RCA), which bought its commercial production rights. It was also the first instrument used in orchestral compositions. Andrey Pashchenko (1885–1972) wrote a concerto-like piece for theremin and orchestra – “Symphonic Mystery” in 1923, it was also first used in a film score by Dmitry Shostakovich in 1931 (film “Odná” – “Alone”). In 1929, Joseph Schillinger composed First Airphonic Suite for Theremin and Orchestra, first performed with the Cleveland Orchestra with Termen himself as soloist. Theremin was heard by a large audience also in 1945, when Hungarian-born Hollywood composer Miklós Rózsa made a feature of it in his score for the Alfred Hitchcock psychological thriller *Spellbound*. Famous conductor Leopold Stokowski is known to have experimented with theremin use in classical repertory arrangements. Edgard Varèse incorporated two theremins in his *Equatorial* (1934), piece for two theremins, bass singer, winds and percussion, though later replaced them with “Ondes Martenots” (Picture 3), another popular early electronic instrument, which is considered as even more successful, partly because it became a favorite instrument of one of the most renowned composers of 20th century – Olivier Messiaen.

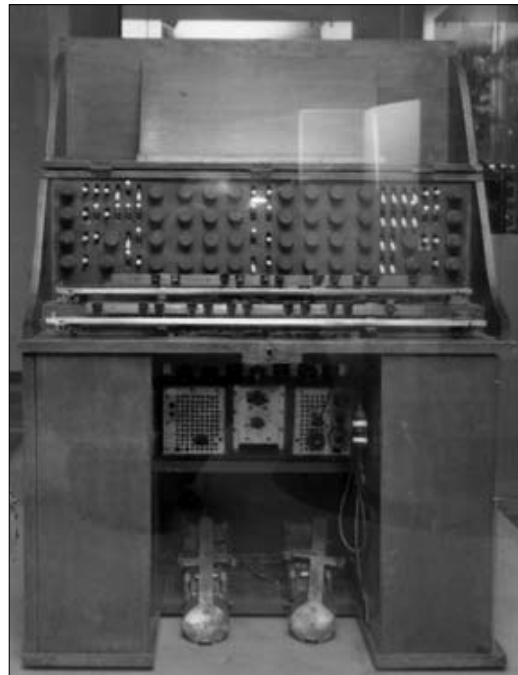
Invented by Maurice Martenot (a cellist, radio telegrapher and inventor) in 1928, Ondes Martenot (“Martenot Waves”) was based on a principle similar to the functioning of the Theremin, however this instrument (as some later version of Theremin) acquired a keyboard. It made its debut in a piece “Poème Symphonique” by Dimitrios Levidis in 1928. Among others who used it shortly after invention were such prominent composers as Darius Milhaud, Arthur Honegger, Charles Koechlin, André Jolivet and others. However probably the interest by Messiaen (his first composition for this electronic instrument was “Fêtes des belles eaux” for 6 Ondes Martenots in 1937) eventually made it widely known. The use of this instrument in Messiaen’s *Turangalila-symphonic* (1948) is probably the most known example of inclusion of an electronic instrument into orchestral score. It occurs also in his “Trois petites liturgies de la présence divine” (1944) and opera “Saint-François d’Assise”. After Messiaen Ondes Martenot became less prominent, however it is still used in film music. Unfortunately, the instrument production ceased in 1988, however its sound can be recreated with digital software synthesizers.

Less known, however still relatively popular was the Trautonium (Picture 4), monophonic electronic music instrument invented in 1929 by musician and physician Friedrich Trautwein in Berlin. His work was continued by Oskar Sala. Instead of a keyboard, it is controlled by a resistor wire stretched over a metal plate. Wire is pressed to create a sound, and volume is controlled by the pressure of the finger. Oskar Sala added noise and additional control generators, filters and subharmonic oscillators, which generate main pitch and harmonics, which are not the multiples of fundamental, but fractions of it. Four of waves can be mixed together, therefore this version of instrument was named “Mixtur-Trautonium”. Student of Paul Hindemith (who also used Trautonium in several short trios), Harald Genzmer composed two concertos for Trautonium and orchestra (composed in 1939 and 1952), both for its monophonic and “Mixtur” versions. The most famous use of Trautonium was by Oskar Sala in Alfred Hitchcock’s film “The Birds”, where he recreated the bird noises with this electronic instrument (1963). Trautonium was also used by Richard Strauss in his “Japanese Festival Music” in 1942 to imitate gongs and bells.

The overview of most popular early electronic music instruments shows, that they have been occasionally incorporated into orchestra, however were usually treated as additional, solo instruments to obtain a specific color. Later instruments (Hammond organ, electric guitar, Moog, ANS and similar synthesizers, next genera-



Picture 3. Ondes Martenot



Picture 4. Trautonium



Picture 5. Contemporary electronic and computer music pioneers: first synthesizers, computers, Hammond organ and electric guitar

tion digital synthesizers based on sophisticated synthesis techniques etc.) have been used in a similar way, namely expanding the sound spectrum and timbral “palette” of specific piece, however their function has never developed even closely to the functions of the traditional orchestral groups.

Previously mentioned instruments like Hammond (electric) organ and electric guitar (both invented in the United States) are the most popular representatives of classical instruments, which were “enhanced” with electronics. Hammond organ (patented in 1934) had especially large impact, over 2 million such instruments have been sold subsequently. However its repertoire was not unique, it was primarily used on radio shows, in churches etc., later instrument became prominent as jazz and rock music organ. Another acoustic instrument given a new sound – the amplified electric guitar – is probably most widely used electric instrument. It was first developed by George Beauchamp in 1931 (who later also patented a electric violin). Considered as a major instrument of jazz and rock genres, it was also used in classical contemporary compositions by Karlheinz Stockhausen, Morton Feldman, George Crumb and others. Electric guitar was included into well-known orchestral scores such as Michael Tippett’s opera “The Knot Garden”, Leonard Bernstein’s “Mass”, Alfred Schnittke’s Symphony No. 1 etc. Lately electric guitar performances with an orchestra became popular in various cross-genre projects, where prominent guitarists like Yngwie Malmsteen, Steve Vai or “Metallica” members play with famous orchestras and conductors.

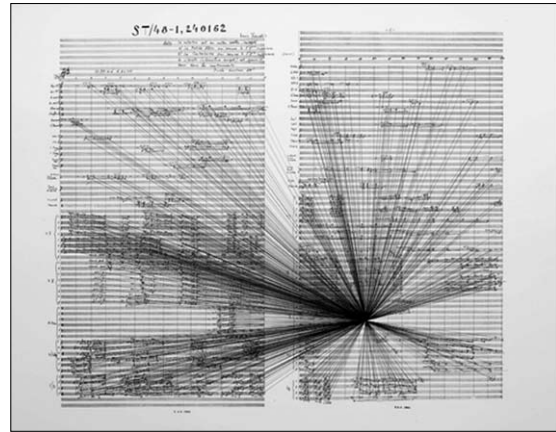
After 1950s, the lead in the invention of electronic instruments was completely passed to the United States and Japan. Developing compact circuitry and computer technologies enabled exploitation of enhanced synthesis techniques, which led to the creation of synthesizer (first based on analogue, later – digital signal processing). These instruments had the ability to generate much richer range of sounds with means to tamper with many sonic parameters. First complex programmable synthesizer, installed in 1957 at Columbia University, was RCA Mark II Sound Synthesizer, most famously advocated by American composers Milton Babbitt and Vladimir Ussachevsky. Although it was quickly surpassed by more advanced (Buchla, Moog) systems, it is worth to note, that RCA Mark II was often associated with unverified story, which claimed, that developers of the synthesizer tried to convince Radio Corporation America (RCA) in the ability of future versions of the machine to replace the symphony orchestra.

About at the same time the first computers were put in use to assist composer by performing calculations according to their needs. One of the most notable early uses was the one by modernist Iannis Xenakis, who often performed complex mathematic calculations in his composition work, especially adapting the theory of probability, which led to the development of composer’s “stochastic method”. In 1962 with help of IBM 7090 situated in Paris, he managed to compose a series of ST (stochastic) computer assisted compositions, including ST/48 for orchestra of 48 instruments (Picture 6).

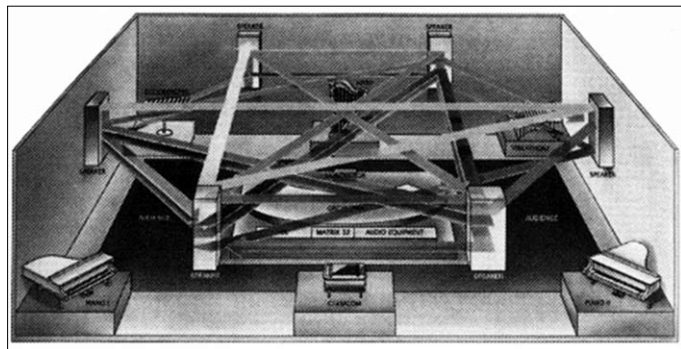
The electroacoustic music, described as the use of electronic sounds together with live instruments at the equal importance, finally led to the origin of so called “live electronics”. One of the compositions, which set the course for the new outlook was *Répons* (1980) by Pierre Boulez. The sophisticated electronic part created in studios before played back from tape and in this way joined with live instruments in concerts. However, *Répons* is a brilliant example of live transformations and electronic manipulations of sound.

Pierre Boulez *Répons* was the first important work, which came out of IRCAM (Institut de Recherche et Coordination Acoustique/Musique). It was first Boulez’s large scale composition after long period of conducting. *Répons* is written for an orchestra, a digital processor, six loudspeakers, and six solo instruments: a harp, a glockenspiel, a vibraphone, a cimbalom (old Hungarian instrument), and two pianos. Composer takes into account spatial relationships between the instruments and the audience, which sits between the orchestra and the six soloists, who are settled around the outer perimeter in between the six loudspeakers (Picture 7). Composition is subdivided into Introduction, 8 sections, and Coda. *Répons* (as the title suggests) is built from a number of responses. It utilizes the medieval composition technique of responsorial mirroring, which is implemented with the help of electronics and unconventional placement of musicians. Computer extends the musical vocabulary by shifting and transforming sounds of solo instruments real-time (live). Live electronics were often used by later prominent composers, especially in chamber orchestra (sinfonietta) works, however the use of new sounds itself are again specific to individual compositions and still remind the role of solo or additional instrument of specifically wanted color.

Recent trends in computer music further the idea of “replacing” the orchestra with virtual means, rather than changing it by introducing new instruments, groups, functions or roles into classical/modern setup. Synthesis technologies are not yet advanced enough (or will never be able) to replicate the sound of live instrument from scratch. However, growing processing power allows the advance of sampling, where recorded separate “bits” performed by a specific live instrument(s) in various manners can be virtually joined together according to the wish of the composer. The so called “orchestral sample libraries” of better and better quality are released each year, with more and more intuitive tools to handle them (Picture 8). “Virtual orchestra” - this term was coined to refer to orchestral simulation with computer. Already now it is widely used in mostly “commercial” music settings, including films, musical theatre, ballet and even opera. Exploitation of a virtual orchestra is often considered as controversial, especially after successful attempts to use it in live performances, and even can be considered as a threat to musicians’ working places. Modern tools for manipulating virtual



Picture 6. First page of ST/48 by Iannis Xenakis



Picture 7. Scheme of *Répons* by Pierre Boulez



Picture 8. “Vienna Symphonic Library” user interface

orchestra give a lot of control to the composer to achieve result, which in some cases probably would not be possible in live orchestral performance. This side of virtual orchestra “phenomenon” is little explored, as the main focus is usually given to its commercial potential.

To conclude this short journey to almost inexistent world of “electronic orchestral music”, we are able to state, that the fundamentals of orchestral tradition were not influenced by electronic and computer music developments in any significant way. Orchestral principles may be used in synthesizers, as well as composing techniques derived from the technological field may be used in orchestral composition, but the orchestra itself remains intact, allowing “intrusion” of electronics only as a guest. Orchestra itself, as an expensive and sophisticated entity, however, may be in some cases threatened by its rapidly developing virtual counterpart. Let’s end with another citation, words of electronic music pioneer, composer and music theoretician Herbert Eimert: “...there has been no extension of traditional procedure. By the radical nature of its technical apparatus, electronic musicis compelled to deal with sound phenomena unknown to musicians of earlier times. The disruption by the electronic means, of the sound world as we have known it leads to new musical possibilities, the ultimate consequences of which can hardly yet be appreciated ... here we touch on a most widespread misconception: namely, the idea that one can make music ‘traditionally’ with electronic means”. In modern context these words sound quite ambiguous, both to the relation of electronic music and orchestra. Would we change, replace or turn any tradition upside down? And, if “yes”, then “why not”?

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### Santrauka

#### Elektroniniai instrumentai ir kompiuterinės technologijos šiuolaikiniame orkestre

„Aš svajoju apie paklūstančius mano mintims instrumentus, kurie savo nauju netikėtų garsų pasauliu bus tinkami mano vidinio ritmo poreikiams“ – šie Edgardo Varèse'o (Niujorkas, 1917) žodžiai labai tiksliai nusakė būsimą posūkį esminių XX ir XXI a. tendencijų link. Nuo pat analoginių ir kompiuterinių technologijų iškilimo muzikos sferoje matome dvi lygiagrečiai besivystančias pagrindines kryptis:

- iš tikslųjų mokslų kilusių ar technologijų palaikomų kompiuterinių procesų taikymas muzikinės medžiagos struktūros organizavimui;
- garso tembro sintezė, transformacija, naujo garsinio spektro paieška.

Reikia pastebėti, jog elektroninių ir kompiuterinių technologijų naudojimui muzikoje visų pirma įtakos turėjo naujų struktūrinių ar skambesio galimybių poreikis. Šis principas labai aktualus ir šiuolaikinio orkestro kontekste.

Pranešime apžvelgiamos bei apibendrinamos elektroninių instrumentų ir kompiuterinių technologijų naudojimo orkestrinėje muzikoje kryptys, jų raida. Aptariami tiek konkretūs elektroninių instrumentų naudojimo orkestre atvejai, tiek ir struktūros organizavimo principų, išplaukiančių iš kompiuterinės muzikos plėtojimų sričių bei klausimų, taikymas.

Elektroniniai instrumentai ir kompiuterinės technologijos negali pakeisti orkestro ar jo galimybių, bet sudaro sąlygas praplėsti šiuolaikinio orkestro skambesio spektrą ir prisidėti prie jo atnaujinimo bei tobulinimo.