

Theremin in the Press: Construing ‘Electrical Music’

Jaime E. Oliver La Rosa
Department of Music - CMC
Columbia University
jo2357@columbia.edu

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Abstract

This paper is not directly about the theremin as a musical instrument nor about its creator Leon Theremin. It is rather about the reactions that the person and the instrument provoked in the general public, and in particular, about the way in which they were documented in the press, between the years 1927 and 1937, when Leon Theremin lived in New York after a brief european tour in his way from Russia. The reactions to the theremin portray a society that embraced modernism, while retaining many romantic values, beliefs and practices that prefigured later reactions to electronic and computer music. These reactions are analyzed in order to identify how ‘electric music’ was first understood, and the way these first responses reflected several expectations of musicians towards technology. Finally, the paper reflects on the effect of the theremin upon modular design and on the introduction of the schematic as an operable code that enabled the transmission of information. This paper belongs to a larger agenda concerned with understanding the way we conceive of a *musical instrument* in the computing era.

1 Introduction

In 1927, Lev Sergeyevich Termen¹ went on a tour of demonstrations and concerts through Frankfurt, Berlin, Paris, London, and finally arrived in New York on December 20th, where he stayed for approximately 10 years. His new instrument, the *etherphone*, or *thereminvox*, or simply the *theremin*², intruded in the musical world causing a commotion in the press and attracting the attention of scientists, the cultural elite, and the general public. As the instrument was demonstrated, it provoked passionate reactions, receiving both praise and criticism. In its path through Europe and well after its arrival in New York, Theremin became a media phenomenon and the world's reaction to the instrument, the myth that grew around it, and the speculations about the new music it heralded were thoroughly documented³.

Negative criticism was generally concerned with pointing out the instrument's inadequacy for the Western concert musical tradition, with actual performance flaws (intonation, incessant vibrato and legato), with the instrument's monophonic nature, and so on. It was also however, a counter-reaction to the media's excessive praise of the new instrument. Visionary or shortsighted, this kind of criticism is, in any case, irrelevant to the aim of this paper.

The theremin provides us with an opportunity. As the first instrument to draw the Western musical world's attention to electric sounds, it stimulated a vigorous debate about what the role of these sounds should be in music and about what this new 'electric' music would be like⁴. In these debates,

¹Also known as Leo or Leon Theremin.

²I will use *theremin*, with lower case t to refer to the instrument, and *Theremin*, with upper case T to refer to the person.

³"This has caused Professor Einstein to say that, as the result of this invention, the world is now relatively in musical development where our Stone Age ancestors were when they first discovered that they could produce sounds by striking implements together" [45]. "The thing is quite as marvellous as the reports from Berlin had led us to believe. The imagination is intoxicated by the musical possibilities latent in the invention. It is the greatest wonder of our time" [44]. "Police were called to keep order among the crowds which thronged to the Opera tonight to hear his concert and many hundreds were turned away. For the first time in the history of the Opera standing room was sold in boxes. ... German musical centres hailed him as the inventor of a new form of music" [50].

⁴"The thing is quite as marvellous as the reports from Berlin had led us to believe. The imagination is intoxicated by the musical possibilities latent in the invention. It is the greatest wonder of our time" [44]. "the optimistic and speculative can claim that by means of an invention, which is a logical and scientific manifestation of the present age, a

a divide was seen between the instruments and music of the past and the “music of the future”⁵.

The central discourse around the theremin is the construal of “electric music” as overcoming of the limitations of the physical world. This allowed the musician to express himself *directly* or *transparently*. The way in which the physical world was surpassed was articulated through several ideals: a sound that is purer and louder than any mechanical sound, and able to have any timbre or pitch desired. The theremin is seen as an immediate experience in the sense that nothing - or at least less - mediates between musician and music, allowing for the translation of thoughts into sounds. Paradoxically, the medium itself is always the center of attention and most critics could not get past it to talk about the music made with it.

I will however argue that the main innovation of the theremin is that music or a musical device can be - and is in fact - expressed as a schematic. The ability to represent the device as information, opened up new possibilities for replication, exchange, education, realization, modification, and so on. These representations will later become central to electronic and computer music practices.

This paper is an extension of my dissertation research in the Computer Music area at the University of California, San Diego under the supervision of Miller Puckette. In this sense, this paper takes part in a larger agenda that tries to understand the way the idea of *musical instrument* has changed throughout the 20th century in which new electric instruments emerged and coexisted with acoustic ones.

2 Electric Instruments and the Ether

2.1 Electric Instruments

First demonstrated in Russia in 1920[33][64], the theremin was not the new instrument has been put into the hands of man which will put him more closely and intimately in touch with the real materials of music than has ever been before, and lead him to new horizons of power and beauty”[7].

⁵This “music of the future” is unlike Wagner’s “artwork of the future”, in that it is designed to name something that not yet existed and which no one could imagine. It was a way of dividing the new music that would be produced by electric or wireless media and that from old mechanic devices. “To be a musician of the future, you may need only to learn how to wave your hands correctly” [28].

first musical instrument to use electricity⁶, nevertheless, the instrument captivated the attention of much of the Western World, because it was performed in an unusual manner: without touching it. While it used electricity, it was not performed with keys, buttons, knobs or switches and although it was a musical instrument it looked like something else.

In the theremin, two antennae propagated electromagnetic fields that varied with the human body's capacitance. This capacitance measurement was largely - yet wrongly - understood as a measurement of the distance between the hands and the antennae. One antenna was used to control the amplitude of the sound and the other one, to control its pitch. The sound was created with the *heterodyning* technique, which used the difference between two high frequency oscillators to obtain a lower, audible frequency. A version of this technique was used in the *ondes martenot* amongst several other instruments. The ranges of the antennae could be adjusted with variable resistances controlled by knobs. 'Timbres' were chosen through selector switches similar to organ 'stops', and were achieved through filters and "by using the inherent irregularities in the response curve of the loudspeaker to accentuate different overtones" [9].

2.2 Ether

Theremin initially named the device *etherphone* and the music it produced, *ether music* or *ether wave music* "to distinguish it from the product of the contact or keyboard method". [53]

In ancient and medieval science *aether* was believed to be the medium that filled the space between planets. In early modern physics and into the 19th century, it was believed to be the medium in which electromagnetic waves propagated.[70] The term became a popular concept to explain the radio's wireless transmission of sounds. Newspapers immediately adopted the term and suddenly people talked about ether music, ethereal music, ether-wave music, musique des ondes etherees, and so on. These terms were gradually replaced with *electric* or *electrical music*.

⁶In his paper *Early Electronic Instruments*, Curtis Roads [33] finds 5 instruments created before 1920, and 14 before the European and American tour that started in late 1927. Furthermore, Theremin showed his instrument in the Frankfurt Fair where Jorg Mäger was presenting his new *sphaerophone*. While Mäger's instrument had more 'timbres', all the attention was captured by the theremin.[1].

Several expressions of wonder about the instrument alluded to religious⁷, and magical⁸ experiences. The aether references also recalled the ideal of the music of the spheres⁹.

2.3 Science, Technology and Musical Practice

The first public presentations of the theremin were both technological demonstrations and musical concerts. While Theremin had cello lessons as a child, he considered himself a physicist and scientist rather than a musician¹⁰ and saw his work as a step “toward [the] electrification of musical acoustics” [53], which he understood as evolution and progress. As it will become evident throughout this paper, a significant trait of the first half of the 20th century was a collective belief that modern electric technologies were superior to their mechanical predecessors.

While Theremin, and many others, saw in the new instrument the “music of the future” it was almost always used to perform music of the past. In a lecture in 1921 Theremin talked about the “goal” of his work being the creation of a “solo instrument” that could “perform the same functions as, for example, the violin, the viola, the violoncello, or corresponding wind instruments such as the clarinet”. He saw his instrument as an improvement to current instruments: “If the instrument were able to produce sounds by responding readily to the free movement of the hands in space, it would have an advantage over traditional instruments” [65].

⁷“... everyone shivered as if they had seen God inflate the dead instrument with life” [Andreas Lunas, *Le Courier Musicale*, 1927 in [9]]

⁸“... making one think of magic and enchanter’s gestures” [44]. “Magic electrical wand produces amazing music from simple little box” [14]. “... the nearest thing to magic one sees nowadays” [39]. “If Leo Theremin had lived 500 years ago he would probably have been burnt as a sorcerer. In mail week his magic held enchanted the thousands of people who filled the Albert Hall” [59]. “... an almost magical demonstration of an entirely new form of music was given” [57]. “Fashionable folk fill opera house to see modest young russian professor’s wizardry” [2].

⁹“One newspaper announced after the Berlin concert that ‘a legend has come true - the spheres resound. The orchestra without instruments has come into being’ ” [49]. “An invisible plectrum, sounding the music of the ‘spheres’, will come true in New York next tuesday evening with the first American demonstration of the ‘ethereal music’ of professor Leo Theremin” [26]]

¹⁰“My object in giving these demonstrations is to prove that science can render to music as much service as it is giving to industry” [46]. “He claimed that the application of science must lead to progress in music” [60].

In this sense, Theremin and many instrument makers of the time, did not attempt to transform the way music was practiced as many practitioners of electronic music did later on. Their inventions were an attempt at better instruments which followed the traditional model of instrument of a stable timbre over which pitch and amplitude are varied. In this sense, the traditional model of Western music practice remained intact: composer - score - performer - instrument - listener.

3 Overcoming the Physical and Material World

3.1 The Voice and the Bowed String

In its first concert-demonstrations, the theremin was usually performed as a soloist instrument with piano accompaniment. The programs consisted of pieces for voice or violin drawn from the Western music repertoire¹¹, and played on the theremin. Gradually original compositions for theremin and piano or orchestra began to appear, due to the emergence of theremin virtuosi like Lucie Bigelow Rosen and Clara Rockmore, and the interest of composers like Joseph Schillinger. Theremin gave these demonstrations at the Paris Opera, Albert Hall in London, Metropolitan Opera House and Carnegie Hall in New York, amongst other musical establishment venues. The use of the theremin in these contexts legitimized it as a musical instrument and prompted associations and comparisons to existing acoustic instruments.

For several reasons, two of the most common associations and comparisons were to the singing voice and to stringed instruments¹². In Russia, the etherphone was also known as the *termenvox*¹³ and several newspaper articles used the term *theremin vox* alluding to Theremin's voice.

Portamento and vibrato were salient features associated with expressivity¹⁴ that were shared with the singing voice and with bowed strings. Para-

¹¹For example, the first public demonstration in New York occurred in the Metropolitan Opera House and consisted of Schubert's *Ave Maria* and "other solos" by Saint-Saëns, Scirabin, Rubinstein, Rimsky-Korsakoff, Mattheson and Glinka[51].

¹²"... a curious cross between a violin note and a human voice"[14]. "A voice suggesting the violin and voice by turns was heard in all parts of the theatre. It was the subject of popular discussion during an intermission that followed"[51]. "a voice so beautiful"[38].

¹³"...soon the man and his invention fused, and the papers began referring to the etherphone as 'Termen's voice' - or the 'Termenvox' [9].

¹⁴"The 'soul' was put into the music by the vibrating right hand, he said"[52]. "The

doxically, these techniques were also the most common criticism of the instrument: it's inability to perform discrete steps or to play a note in tune without vibrato.

3.2 Immediacy

The fact that portamento was always present, created the feeling that every detail of the performer's movements was translated into sound and therefore nothing could be concealed from the audience. This overtness was initially understood as electric media's overcoming of the limitations of the physical / material world.

Perceived to be an interface-less instrument, the performer on the theremin did not manipulate object¹⁵, but rather, the ether itself¹⁶. This immateriality furthered the connection to the singing voice¹⁷. Moreover, for some the medium actually disappeared¹⁸ and the performer was enabled to express himself *directly* to the audience. The absence of the medium was associated with musical freedom as the performer could now become unaware of the existence of the medium and focus exclusively on the music¹⁹. This directness was usually expressed in terms of the musicians personality and connection to the music²⁰. The idea was carried on to the extreme where the musicians

sounds thus produced have a purely mechanical character and are uttered with a cold brutality which might put off the public. To give them 'life', in the sense traditionally understood by musicians, Professor Theremin imprints his right hand upon the vibrating wave a tremolo exactly similar to that used by violinists. ... The effect is extremely attractive to the public and brings back the great electric voice to the reassuring aesthetic of the cello" [68].

¹⁵"...it is the first time that music has been extracted from something instead of being put into something" [52].

¹⁶"... no wood, no steel, no string, no horsehair" [52]. "... produces beautiful music from air, without keys, pipes, wires or other instrumental devices" [13]. "There is no keyboard to obtrude itself, no catgut, no bow, no pedal, nothing but simple expressive gestures of the hands" [16] "...it allows the musician to express his most intimate musical thought without material limitations" [38].

¹⁷"Ether wave music is created with a simplicity and a directness matched only by singing". Theremin in [16].

¹⁸"...there is nothing between the human being and the music itself" [52].

¹⁹"The musician ought never to be conscious of his instrument or of his technic when he plays as an artist. But the keyboard, the bow and the catgut constantly interpose and prevent him from obtaining true freedom. What can be freer than the movement of hands in empty space to produce beautiful sounds?" [15].

²⁰"... music springing from the individuality of the artist" [53]. "... [an] unembarrassed

thoughts and brain were translated directly onto sound²¹.

As we will see later, this perceived immediacy and seeming immateriality of the theremin gave rise to multiple beliefs, of which one of the most extreme was that it was *better* than all existing instruments in every aspect. From this beliefs stemmed others: that it would be very easy to play or that it would be able to replace any instrument, leading to new commercial products and musical experiments.

3.3 Pure Sound

Public reaction to the theremin often referred to its sound as pure²². The theremin was commonly associated with a near-sinusoidal sound. The absence of the mechanical noises of blown air, bows, or keys, reinforced the association with the voice as a sound that was pure, an ideal to which vocal technique in the Western world has aspired throughout its history²³. Purity was often connected to the religious or superhuman qualities mentioned earlier²⁴.

The forcibly continuous changes in pitch (portamento) and amplitude made it clear that the interface and the articulation of the sound of the

medium for the expression of the musician's personality" [52]. "... more intimate connection of these sounds with the individuality of the performing artist" [53]. "... the personality of the performer is more sensitively presented than on any existing instrument" [52].

²¹"Russian Engineer turns thoughts to tones" [41]. "... most perfect medium existing for translating the musician's thoughts into music" [41]. "... shortened the path from the brain of a human being to matter". in [9]. "... also won paris, which loves any example of mental victory over matter" [2]. "Call it translation of musical thought" [62].

²²"it is possible to obtain tones of the utmost purity" [58]. "sounds of perfect musical quality" [30]. The singer Elizabeth Rethberg said: "It was surprising to me to find that it had no mechanical tone. It seemed to have a soul" [52]. A critic in London's *The Daily Telegraph* "found the experience ... quite uncanny. The purity of the tone he extracts is remarkable" [9]. "... remarkably pure and sonorous" [40].

²³Electronic music composers in mid-20th Century Germany such as K. Stockhausen and H. Eimert would refer to sinusoids as pure sounds. Computer musicians now search for ways of adding imperfections to the perfection of machine generated sound waves and performances.

²⁴"... the great electric voice" [68]. "... the most celestial sounds, like those of a glorified stringed instrument" [38]. "... a superstringed instrument and a superhuman voice" [38]. "... an archangel's voice, of five octaves, and incredible power and sweetness, that can dive to the rich low tones of a cello, and include the thin high harmonics of the violin; that can be heard in great spaces without effort, through and above a great orchestra, blending with all other instruments and voices" [Lucie Bigelow Rosen in [9]].

theremin were inevitably related, while the timbre it produced was for the most part independent of the gestures of the performer. In other words, the performer's actions accounted for both pitch and amplitude, but not fully for timbre.

In contrast, the immateriality of the interface did somehow account for the theremin's unusually 'clean' sound, devoid of the noises that characterized physical mechanisms based on bowing, blowing, plucking, hammering, and so on. In the theremin, the interface was silent and the sound strictly electric.

Theremin designed a fingerboard model of the instrument in 1922. In 1929, he developed a new version, commissioned by the conductor Leopold Stokowski, and inaugurated in the same year as part of the Philadelphia Orchestra. The 'fingerboard' model, in contrast to the 'space-control' model - with which we have been dealing so far - alluded directly to the cello, not only through its sound, but also through the shape of its interface, performance posture, and fingering technique.

Stokowski thought of the 'fingerboard' model as "a cello, but without strings" and the composer Joseph Schillinger described it as having an "idealized cello tone" [Schillinger in [9]]. The absence of strings effected the transition from mechanical forms of sound production to electric ones. The sound of the bow and string - and all the noises that result from their friction - are in fact the sound of the cello, and not the "idealized cello tone" of the theremin. In this respect, Schillinger's allusion to an "idealized cello tone" reflects the Western world's division between noise and sound and its desire to get rid of these undesired artifacts of sound production.

3.4 Electric Power

Theremin declared that his instrument was loud enough "for 150,000 people to hear" [in [9]]. He presented it in "several large local auditoriums" [47] and actually played it for an audience "of 12,000 in Lewisohn Stadium" [48]. For some, the instrument had unlimited volume²⁵ and others began to measure its power with acoustic instruments as the unit²⁶.

²⁵"The device was said to have practically unlimited volume of sound and range of tonal color" [47]. "... in its first hearing in the open air it showed possibilities of practically unlimited volume, tonal color and considerable flexibility" [48].

²⁶"... the equivalent of thirty instruments" [29]. "... a tone which rivals that of a bank of stringed instruments approximately the combined effect of a battery of first and second violins, violin cellos and bass violins" [19].

First Airphonic Suite was the first theremin concerto. It was written by Joseph Schillinger and premiered in 1929 by the Cleveland orchestra conducted by Nikolai Sokoloff with Theremin as the soloist. Both in the premiere of *First Airphonic Suite* and in the Lewisohn Stadium concert, critics were baffled mainly by the loudness of the instrument relative to the orchestra²⁷. The symphonic orchestra - the Western world's largest musical organization and symbol of musical evolution - had gradually developed over centuries towards the ideals of timbral diversity and dynamic range. All of a sudden, the orchestra was overbalanced by Theremin, "a grave and slender figure in evening clothes" who "made the slightest motions in front of two bars" [in [9]]. *The New York Times'* Olin Downes went as far as to say that the theremin had "horribly magnified sonorities" that preluded "terrifying instrumental days which are just before us", and worried about the wellness of "auditory nerves" [9].

Once again, the limitations of the mechanical and physical world seemed to be surpassed as a man with a loudspeaker could overpower a whole orchestra. But more importantly, the theremin (and with it, electric music) revealed an instrument in which sound was not directly proportional to the energy or force applied to it²⁸. "The slightest motions" could indeed create a sound as loud as the amplification system would allow it and the theremin could well be made to play 'for ever'[52].

3.5 Timbre

As noted earlier, the timbre of the instrument was not dependent upon

²⁷"He played as if he were conducting an orchestra" [44]. "... showed something akin to scorn for insignificant horns and strings, notwithstanding their number ... loud, full tones ... insisted on acting as the leader for all musicians, somewhat to the annoyance of the concertmaster and the chagrin of Mr. van Hoogstraten, the usual conductor" [48]. *New York Telegram's* Oscar Thompson described that "at times [the theremin was] enveloping the whole orchestra as with a gigantic human voice" and the press talked of "colossal outwellings of sound" and of the disturbance of "seismographs in every observatory this side of Tokyo" [in [9]].

²⁸"This instrument no longer has to take into consideration the limitations of the performer, or the length of his bow which, in particular, has exercised a hidden but decisive tyranny over every composition" [68]. Violinist Joseph Szigeti noted that "the performer on this instrument can hold a note forever, or at least, as long as his hands could hold up ... a singer is limited by his lung capacity, and a violinist by the length of his bow, but there is no limitation of on this instrument" [52].

the performer’s actions, but on the design of the circuit. The theremin had continuous controls for pitch and amplitude, but buttons and switches to select timbres. In some of its many designs, timbre worked through ‘stops’, similar to the stops of organs²⁹.

The RCA theremin was the first commercial model to be produced. It did not have timbre stops, but *a* single timbre. By choosing over a set of timbres as in the first and latest models, or by limiting the instrument to one timbre as in the RCA commercial model, timbre was *designed*. This timbre would be *the* timbre of the theremin, or at least of the RCA theremin. The choice was to create a harmonic³⁰ sound that alluded to known instruments like the voice or the violin, but even beyond that, it alluded to an ideal timbre. According to Glinsky, “the characteristics of the individual tubes were designed to allow a pleasing combination of overtones in the sound” [9].

At the same time, the theremin was being portrayed as an instrument capable of all timbres³¹ and, as we will see later, the idea of a universal instrument began to emerge. The pipe organ had already incited the ideal of having an instrument that could imitate the sounds of other instruments, and in which timbre could be designed. For this reason, the press referred to the timbre buttons in the theremin as organ stops. While the theremin was commonly associated with the singing voice and bowed strings, its ability to imitate “all known instruments” was a recurrent claim made by Theremin in his concert demonstrations. The press often validated these affirmations³². Alluding perhaps to the ideal of purity mentioned earlier, Theremin and the press went further by claiming that the sounds of the theremin were even better than those of the acoustic instruments it imitated³³.

²⁹“... musical synthesis possible by manoeuvring registers, as in an organ” [2].

³⁰A sound that contains harmonics or partials with frequencies based on the harmonic series and varying amplitudes.

³¹“With its aid anyone can produce every conceivable sound, familiar and unfamiliar” [66]. “The device was said to have practically unlimited range of tonal color” [47].

³²“... string, wind and brass are mimicked with absolute fidelity” [16]. “Device that imitates many instruments” [56]. “... while this tone at will can be made to resemble that of a violin, piano, or trumpet” [13]. “... could imitate any variety of musical sound, at one moment producing the clear notes of a flute, and at the next mimicking the tone qualities of a violin or sinking into the deep murmuring of a double bass. Even the beating of a drum could be reproduced ... by a special movement of the hands, an echo could be heard” [57]. “... the different characteristic timbres of voices as well as instruments” [58].

³³“... the tone is richer and fuller than existing instruments” [13]. “... With this instrument I have made it possible to produce tones of constancy of pitch not even remotely

The theremin was also able to produce non-instrumental sounds to which the press referred to as the “weirdest discords” [37] or “mere noise” (*Birmingham Post* in [9]). The press, perhaps conditioned by Theremin’s claims, made further associations beyond the world of instrumental sounds identifying “... bellows, moans, child-like whimperings, a very realistic bleating of sheep” (ibid.) and “... [sounds] like those of a motor-horn and a factory syren” (*Newcastle Journal* in [9]). In other words, as they confronted sounds that didn’t conform to any of the instrumental categories, these were associated with sources beyond the realm of romantic music: noise. Sokoloff described the theremin as occasionally producing “the most unearthly, ear-splitting shriek” [9], which in the first rehearsal of the Airphonic Suite, “caused the first horn to faint”. These undesired noises were generally avoided and eventually shown as curiosities.

However contradictory, Theremin stated that it was “not his wish in any way to imitate the tone of any particular instrument with his invention” [61], but instead to add “an entirely new range of tone colors. Hitherto the composer has had only about twenty tone colors, represented by as many types of orchestral instruments. I give him literally thousands of tone colors” [16]. All of these “tone colors” however, seemed to belong to the same source: the theremin.

Since the work of Grey [11] and Wessel [69], timbre is not simply an instant spectrum, but a complex phenomenon that involves time varying phenomena, such as the nature of the attack. In this sense, the timbre of the theremin is determined not only by its spectrum, but by the continuous manner in which sound is articulated. Because of this fact, although one is able to choose different ‘timbres’ through stops, all of these different timbres sound like a theremin. In other words, if we understand timbre to be the way we recognize a sound to belong to the same instrument, then “the sound” of the theremin is determined and recognized more by its articulation than by any particular combination of overtones.

approached by the best piano or organ” [16]. Theremin in the *Chicago Tribune*: ... “[I can] produce equally well the sounds of a violin, an alto or a trumpet. The quality of the sound of my apparatus is even better than that of the instruments themselves” [9].

4 The Interface

4.1 Dissociation of Interface and Sound Production

As the popularity of the theremin grew, accusations of plagiarism appeared sporadically in the Press. In the United States, some inventors claimed that their patents had been violated³⁴ and legal action was taken against RCA for the use of the *audion*³⁵ in the theremin[9]. In France the claim was that Givelet had already used the heterodyning principle³⁶. Theremin acknowledged he had used “pioneering inventions”[53] in his design, but he saw in the interface and its control possibilities his real contribution to music³⁷.

Setting aside the issues of copyright and transfer of knowledge, interesting in their own right, the theremin was conceptually divided into interface and sound generation device.

Theremin developed several interfaces to control the heterodyning principle. The “space-control” model based on the two antennae is certainly the most well known, but there were several variations. Goldberg, an assistant to Theremin, had developed a version with pedals to control amplitude and a series of buttons to control articulation. Theremin also built a “fingerboard” model mentioned earlier, a keyboard model, and the *terpsitone*, a floor surface which was to be played by dancing. All of these models used the heterodyning principle and so did the inventions of Mäger, Givelet, Martenot and several other instrument builders of the time.

³⁴“Disputes Invention of ‘Ether Music’. Dr. F. E. Miller Asserts Method of Theremin Is Variation of His Patent of 1921”[53].

³⁵A vacuum tube oscillator invented and patented by Lee De Forest which Theremin used in his design.

³⁶“... electricity is converted into sound (Didn’t Mr. Givelet, vice president of *Radio-Club de France*, demonstrate the principle not that long ago?”)[21](My Translation). “But to be fair, Theremin was not the first to go in this direction. Two french engineers had preceded him, obscurely and without their experiments decreasing whatever the undoubted originality of Professor Theremin. Yet Mr. Givelet with its radio-electric organ and Mr. Toulon, with its photo-electric piano, had already clearly stated the problem, but failed to resolve it satisfactorily with their own means”[6](My Translation).

³⁷I visualize great possibilities in connection with the problem of controlling sound material by means other than mechanical, by the free movements of the hands in the air, which offer more intimate connection of these sounds with the individuality of the performing artist, and make available not only the expressive power of existing instruments but perhaps even greater possibilities.[53]

However, because the interface was separate from the sound production device, many different interfaces could have the same sound, and, as seen earlier, the same interface could have different sounds. In contrast to most instruments, there was no manipulation of an object that also produced the sounds. The sounds were dissociated from the gesture making them as they were produced by loudspeakers away from the gestures of the performer³⁸. While there was a precedent with the organ's use of the keyboard interface, the electric era provided for a degree of flexibility and portability hitherto unattainable.

4.2 Immediacy and Ease of Use

As stated above, the theremin was perceived as more immediate than traditional instruments. This perception was based on the invisibility of the interface and the transparency with which the sound reflected every move of the performer. The interface was literally invisible except for the referential position of the antennae. What actually controlled the sound was capacitance in an invisible electromagnetic field, a fact that rendered the instrument both spectacular and magical, as well as extremely hard to play. Because the instrument worked by sensing capacitance any movement the performer made affected the sound. Clara Rockmore told Theremin "you can hardly breathe on that instrument without affecting something ... you cannot register any of your internal emotion at all. You cannot shake your head, for instance, or sway back and forth on your feet. That would change your tone" [in[9]].

In the theremin all the tactile feedback of working directly with a vibrating object disappeared. The performers were expected to develop their own technique and to adjust, by auditory feedback alone and by practice, the way in which they played a piece. Performing through continuous adaptation through feedback provoked the already mentioned metaphors of singing and whistling.

Although playing a violin or voice piece correctly in the theremin proved extremely hard, it was very easy to play anything poorly. Because in the theremin, the timbre was independent from the gestural input, the problem of producing a "good" sound - as a student encounters in the first violin lessons - seemed to be solved. The theremin was portrayed as an easy instrument

³⁸ "... sweet music resounded from the instrument, but it really seemed to come from the ceiling" [56]. "Theremin brought from his loud-speakers music of a quality which astonished the audience and brought forth applause after each of his program numbers" [52].

to play and often the public was told that if they could sing or whistle, then they could easily learn to play the instrument³⁹. In some cases, writers went as far as to say that music played almost automatically from the theremin without any effort⁴⁰.

That a “good” sound would automatically result regardless of whose hand approached the instrument was an early example of automation⁴¹. This simple automation led to dreams of automatic electric machines capable of independent operation.

4.3 A Universal Musical Instrument and the Orchestra Without Instruments

The RCA advertising brochure predicted that the instrument was “destined to be the universal musical instrument; people will play it as easily, and naturally, as they now write or walk”. [32]

In the mid 1920’s the Russian press wrote in reaction to a theremin demonstration that “the problem of producing the ideal instrument is solved” [9]. Electric instruments were often perceived as the route to reaching a universal instrument. For RCA, it was the instrument everyone could play⁴² and because the theremin was able to reproduce the timbre of any instrument, all acoustic instruments could be replaced.

Following this logic, both Theremin and Stokowski started thinking of an electric orchestra whose instruments would, in Theremin’s view, “have the sound character of the various orchestral instruments”. Stokowski believed this orchestra would “begin a new era in music, just as modern materials and methods of construction have produced a new era in architecture, of which the sky scraper is one phase”. In his view the electric instruments would be added “to the present orchestra only for the music of the future”, but he was forced to postpone his plans due to objections from the union[9].

³⁹“It is claimed that anyone who can hum or whistle a tune is able to produce whatever music he wishes from the Theremin. Little technical knowledge, practice or study is necessary in order to play it”[43]. “... to anyone that has the gift of music he promises that he would be able to play with his invention in a fortnight what a violinist can play only after years of training”[44]. “... the mastery of which he claims, may be attained by anyone having a normal musical ear”[61].

⁴⁰“Inventor waves hand over invisible keyboard and classics pour forth”[42].

⁴¹understood as a device or process that works with little or no direct human control.

⁴²“A child .. an elderly lady ... a skilled musician ... a blind man ... all can learn to play this incredible instrument with exactly the same facility!”[32]

Unions feared an electric orchestra because, according to the speculations of the press, such orchestra would in theory reduce the number of players as the electric instruments were perceived as timbrally diverse and powerful enough to reduce the number of instruments⁴³ and with them the number of jobs and moreover, these instruments were perceived as easy enough to be performed by anyone, putting the few jobs left at risk.

Theremin had an even more radical vision for an electric orchestra: “The time is coming when an entire orchestra will play without instruments. Then, before each musician there will stand only a music stand with music and on it two antennae, and through waves of the air an entire orchestral work will be played - string, winds, drums - all” [9]. The press accompanied theremin’s vision with inspired imagination⁴⁴ as they announced: “the orchestra without instruments has come into being”[49].

The universal instrument was an invisible instrument or, metaphorically, a non-instrument. In other words, the ideal medium was the non-medium; the ideal mediation: immediacy.

5 The Theremin and Modernism

5.1 Breaking Free

Western musicians in the first half of the XXth century felt the need to break with musical tradition and establish themselves as modern. Modernity

⁴³“... an orchestra of forty of these machines”[25]. “The power of the instruments will make it possible to reduce materially the number of players”[30]. “Because a variety of timbres can be obtained at the will of the performer, only sixteen instruments are needed of full orchestra”[54].

⁴⁴“At this future - and futuristic - concert no instrument will be seen, unless loudspeakers, music stands with antennae, and electrical apparatus concealed about the premises be reckoned as such. Wild-eyed musicians will sit at the music racks and flourish their paws in the air. Their movements will be even more eccentric and incomprehensible than they are now. They will stir restlessly in their chairs, describing strange angles and ellipses by their gestures. As the climax gathers to break in a gigantic crashing wave of tone these musicians will leap in the air, reaching for an imaginary mark suspended in the atmosphere above them ...”[7]. “Imagine, then, the Theremin electrical symphonic orchestra of the future! A hundred men stand before sheets of music. No horns, no violins, no clarinets - nothing in sight but the players and the music. The conductor raises his baton. The massive chords that open Beethoven’s Fifth Symphony are heard - that soul-stirring knocking of Fate at the portal of life. The players simply wave their arms. They seem to grasp the music out of the air”[15].

was often verbalized in manifestos, statements and treatises which called for new sonorities, instruments, scales, and of the notion of “architecture”; this break was characterized as musical freedom.

“Away! Let us break out since we cannot much longer restrain our desire to create finally a new musical reality” demanded Luigi Russolo in his *Art of Noise* from 1913[35]. In his view, modernity was to be achieved by opening up the sound world to include noises of all kinds, but he also talked of “quarter pitches” and of an “enharmonic scale” in which pitch changed continuously⁴⁵. Russolo believed that traditional musical instruments should be discarded and new ones created.

Ferruccio Busoni had become aware of Thaddeus Cahill’s *Telharmonium* and in his *Sketch of a New Aesthetic of Music* from 1907[4], showed considerable excitement over the possibilities of addressing sounds with mathematical precision and achieving “infinite gradations of the octave”⁴⁶. The metaphor of gliding emerged in Busoni’s writings as “floating on air”⁴⁷. The idea of “infinite gradations of the octave” - and with it microtonal music - was presented as a complementary concept to that of the gliding tone.

In his collection of lectures entitled *The Liberation of Sound*[67], Edgard Vàrese, a former student of Busoni, called for a break too. In a lecture entitled “New Instruments and New Music” given at Mary Austin House in Santa Fe in 1936, the idea of gliding was presented as that of “flow” and again, the argument of creating new instruments in order to create a new sound world emerged⁴⁸. In a later lecture entitled “The Electronic Medium”

⁴⁵“Each noise possesses among its irregular vibrations a predominant basic pitch. This will make it easy to obtain, while building instruments meant to produce this sound, a very wide variety of pitches, half-pitches and quarter-pitches ... change pitch by enharmonic gradations and never by leaps in pitch. For example, the howling of the wind produces complete scales in rising and falling. These scales are neither diatonic nor chromatic, they are enharmonic”[35].

⁴⁶“I refer to an invention by Dr. Thaddeus Cahill. He has constructed a comprehensive apparatus which makes it possible to transform an electric current into a fixed and mathematically exact number of vibrations. As pitch depends on the number of vibrations, and the apparatus may be ‘set’ on any number desired, the infinite gradation of the octave may be accomplished by merely moving a lever corresponding to the pointer of a quadrant”[4].

⁴⁷“Who has not dreamt that he could float on air? and firmly believed his dream to be reality? - Let us take thought, how music may be restored to its primitive, natural essence; let us free it from architectonic, acoustic and esthetic dogmas; let it be pure invention and sentiment, in harmonies, in forms, in tone-colors ... Yet Nature created an infinite gradation - infinite! Who still knows it nowadays”[4].

⁴⁸“When new instruments will allow me to write music as I conceive it, taking the

given at Yale in 1962, gliding tones or “curves” were presented as a long-time desire that technology allowed him to seamlessly fulfill⁴⁹.

Percy Grainger, also a former student of Busoni, developed an aesthetic and philosophy of his own which he described in a statement on *Free Music* written in 1938[10]. Again, the idea of freedom as gliding or curves emerged tied both to nature and to modernity⁵⁰.

Theremin was no exception to this modern ethos of freedom:

“By freeing him from physical contact with strings, keys or mouthpieces Theremin believes that he has given him something like psychic freedom”[15].

“My apparatus frees the composer from the despotism of the twelve-note tempered piano scale, to which even violinists must adapt themselves. The composer can now construct a scale of the intervals desired. He can have intervals of thirteenths, if he wants them. In fact any gradation detectable by the human ear can be produced”[16].

5.2 1930’s New York: The Glide of Modernity

Theremin and several critics talked of *microtonal* or *fractional* music as one of the theremin’s greatest virtues and as an answer to contemporary musical searches⁵¹. In a dominating system where pitch was the most significant aspect of a sound, micro-tonal music promised an unexplored terrain for

place of the linear counterpoint, the movement of sound-masses, of shifting planes, will be clearly perceived. ... There will no longer be the old conception of melody or interplay of melodies. The entire work will be a melodic totality. The entire work will flow as a river flows”[67].

⁴⁹“For instance, I have always felt the need of a kind of continuous flowing curve that instruments could not give me. That is why I used sirens in several of my works. Today such effects are easily obtainable by electronic means”[67].

⁵⁰“It seems to me absurd to live in an age of flying and yet not to be able to execute tonal glides and curves - just as absurd as it would be to have to paint a portrait in little squares (as in the case of mosaic) and not to be able to use every type of curved lines ... Out in nature we hear all kinds of lovely and touching “free”; (non-harmonic) combinations of tones, yet we are unable to take up these beauties and expressivenesses into the art of music because of our archaic notions of harmony”[10].

⁵¹“by capturing the music from the air, they seem to have caught with it all the quarter-tones, nuances, timbres and sonorities that have been haunting the brains of musical experimentalists these last 25 years”[38].

pitch relations. Critics thus saw in microtonality a natural route for music's development and the theremin, and talked of "quarter-tone" or "unheard-of" scales⁵². However, what attracted several composers to the theremin was not the search for new scales, but the gliding tone.

Like Theremin, composers Edgard Vàrese, Henry Cowell, Percy Grainger and John Cage lived in New York in the 1930's. At around the same time of the conception of "elastic form" [34], Cowell wrote to Cage in 1937 saying: "I honestly believe and formally predict that the immediate future of music lies in the bringing of percussion on one hand, and sliding tones on the other, to as great a state of perfection in construction of composition and flexibility of handling on instruments as older elements are now" [23][34]. John Cage was very critical of the use of the theremin's usual romantic repertoire, which he considered to be an attempt to please audiences ignoring the instrument's true potential⁵³. He later used a - non-theremin- gliding tone as musical material in his work *Imaginary Landscape No.1* for two variable-speed turntables, frequency recordings, piano, and cymbal, in 1939.

Edgard Varèse, who had already used sirens in *Ionisation* (1929-31), had Theremin build him two fingerboard model theremins according to his specifications to use them in his piece *Ecuatorial* premiered in 1934[18]. The theremins are used throughout the piece in its full register (up to 12,544.2 Hz or G9). The piece makes extensive use of the gliding tone, however vibrato is hardly heard. Vibrato had so far been perceived as one of the theremin's most expressive devices, yet some critics - and probably Varèse - saw in the non-vibrato sound a genuinely new sound⁵⁴. In the absence of fingerboard

⁵²"... the quarter-tone scale could be played"[57]. "Infinite gradations of tone are possible ... Because such fine gradations can be attained, Theremin speaks of a new kind of music based on unheard-of scales"[15].

⁵³"Most inventors of electrical instruments have attempted to imitate eighteenth- and nineteenth-century instruments, just as early automobile designers copied the carriage. ... When Theremin provided an instrument with genuinely new possibilities, Thereminists did their utmost to make the instrument sound like some old instrument, giving it a sickeningly sweet vibrato, and performing upon it, with difficulty, masterpieces from the past. Although the instrument is capable of a wide variety of sound qualities, obtained by the turning of a dial, Thereminists act as censors, giving the public those sounds they think the public will like. We are shielded from new sound experiences"[5].

⁵⁴"In the course of the technical preface preceding his little concert, Professor Theremin let us hear, with a rather imprudent disdain, the sounds that his instrument could produce in its pure state, before the intervention of his manual tremolo. Well! these rude tones that can be obtained at will in a murmur or a "howl" offer an extremely interesting new sound material. This instrument of tomorrow should not allow itself to be hampered by

theremins in the 1950's⁵⁵, Varèse re-scored the piece for two ondes martenot.

In 1935, Percy Grainger adapted his *Free Music No.1*, originally for string quartet so it would be played by theremins. In 1937, he began to write *Free Music No.2* for six theremins. His works, notated on graph paper, consisted entirely of gliding tones on the theremin.

5.3 Automation - Turning Thoughts into Sound

Financed by Charles Ives, Henry Cowell had been working with Theremin on an instrument that was able to automatically play multiple complex polyrhythms at the same time, using different frequencies from the harmonic series, called the *Rhythmicon*. While it was acted upon by pressing keys in a keyboard, each key generated rhythmically superimposed overtones automated over time. Automation thus took a new role in the electric age.

The theremin not only created visions of music without instruments, but of instruments without performers⁵⁶. In this way, the immediacy and directness with which the theremin was associated and which reached an extreme in the instrument-less orchestra, now went beyond this boundary to dispose of performers as well. Such claims precluded the discourse surrounding the studios of the 1950's, where electronic music was idealized as a direct medium whereby composers could “speak” directly to the audience by working with the sounds themselves.

Much earlier, Varèse had called for “instruments obedient to [his] thought” [67], and after his experience with *Ecuatorial*, he felt great disillusion with the human-performed theremins deciding - at least temporarily - to no longer compose “for instruments to be played by men: I am inhibited by the absence of adequate electronic instruments for which I conceive my music” [18]. Grainger took these ideas further:

“Free Music demands a non-human performance. Like most true

the orchestral traditions of yesterday. It should bring to the world a new voice, absolutely individual of which we cannot yet suspect all the inflections. This great pathetic cry of the subjugated wave has a poignant quality which we must not seek to destroy” [68].

⁵⁵And in the absence of Theremin himself who, under somewhat unclear circumstances, “disappeared” from New York in 1938, as he sailed back to Russia (voluntarily according to [9]).

⁵⁶“At the most, we have hope of an orchestra without players and without conductor; a musical mechanism acted upon directly by the composer, nothing intervening between him and his hearers, not even an interpreter” [72]

music, it is an emotional, not a cerebral, product and should pass direct from the imagination of the composer to the ear of the listener by way of delicately controlled musical machines. Too long has music been subject to the limitations of the human hand, and subject to the interfering interpretation of a middle-man: the performer. A composer wants to speak to his public direct. Machines (if properly constructed and properly written for) are capable of niceties of emotional expression impossible to a human performer. That is why I write my Free Music for theremins - the most perfect tonal instruments I know” [10].

Grainger envisioned and even planned with Theremin the construction of automated models of the instrument, but Theremin’s “disappearance” frustrated his immediate plans. Grainger later realized these ideas by conceiving and building actual machines, anticipating later devices like Xenakis’ UPIC system [20][17].

5.4 Aliens and Psychos

The reactions of the press and the general public often included the words uncanny, mysterious, unearthly and otherworldly. The once praised purity of its sound, devoid of the noises that linked sounds to the physical, mechanical world, suggested that they were in fact the sounds from some other world. The sounds of the electric world of radio and the phonograph had a documentary character; that of storage and transmission of the sounds of this world, but electronically generated sounds, like that of the theremin, had the quality of the non-physical or “super-natural”, which in the popular imaginary meant outer space as alien life⁵⁷.

Composer Miklos Rozsa used the theremin for the soundtrack of the 1945 movie *Spellbound* by Alfred Hitchcock which was received with great success. The theremin was used to portray the main character’s drunkenness and unbalanced state of mind. It was later used in other movies such as *The day the earth stood still* directed by Robert Wise and scored by Bernard Herrmann in

⁵⁷ “Theremin raised an astronomical window and let be heard a pair of singers from the planet Mars” [72]. “... the question arises, whether that which Mr. Theremin invites from the ether will have value or not in ordinary terrestrial art” [72]. “... extraordinary enough to suggest to almost everyone present that it might be a tune from another world” [59].

1951⁵⁸. In this case, aliens came to earth. Thereafter, Dr. Samuel Hoffman became the thereminist of choice for science-fiction and thriller movies, appearing in multiple TV shows demonstrating and performing the theremin. In 1947, he performed in Revel and Baxter’s record *Music Out of the Moon*⁵⁹, and in 1950 he reached the status of “Man of the Week”.

In Glinsky’s words:

The sound relegated the theremin to a specialized music tool, like an infrequently played percussion instrument, and not the all-purpose expressive medium Theremin hoped it would become. The instrument began to be typed in the popular imagination as a harbinger of the strange and weird - associated with a world outside the boundaries of everyday emotional experience [9].

6 Product and Information Flow

6.1 Mass Production and Standardization

The press would constantly speculate about agreements or offers to mass-produce theremins. The magical, quasi-hypnotic effect of the instrument, its ability to attract large crowds, an automatic “pleasing” timbre and its perceived ease of performance, added to the prospect of low fabrication costs, entertained the idea of commercial success⁶⁰. Seizing on the opportunity, in March 12, 1929, Theremin signed an agreement with RCA to develop a commercial version, and on September 23, the RCA Theremin was announced and sales began.

The RCA Theremin had a fixed timbre and pitch range and became the first mass-produced, standardized version of the instrument. RCA expected to sell theremins for “every home”. They produced a first set of 500 instruments to test the market and although all of the units were sold, it generated a loss. Patent costs paid to Theremin, merchandising expenditures, problems

⁵⁸Other movies included *Rocketship X-M* (1950), *The Thing from Another Planet* (1951), and *It Came from Outer Space* (1953)[71].

⁵⁹Featuring the pieces *Lunar Rhapsody*, *Moon Moods*, *Lunette*, *Celestial Nocturne*, *Mist O’ The Moon* and *Radar Blues*.

⁶⁰“It is not very expensive, costing about as much as a six-tube receiving set” [41]. “An instrument so simple to play and possessing such remarkable qualities of tone and pitch, will undoubtedly have a strong popular appeal” [43].

springing from technical malfunctions, legal suits about patent violations, and the beginning of the depression era, prevented them from pursuing the instrument's commercialization any further.

Glinsky was able to track an internal document from George H. Clark, manager of RCA's show division to "RCA executives summarizing his observations at radio fairs, based on discussions with the public" and suggested several changes that could be done to the instrument in order to improve sales. Among the many recommendations, Clark suggested that the instrument be modified so that it could be operated while sitting, pitch could be controlled horizontally (with high pitches on the right and lower on the left of the performer), a scale would be provided as a reference for pitch, volume control would not be controlled manually, leaving the other hand free to play another voice, and so on⁶¹. In short, the public was really looking for an electric organ.

6.2 DIY

RCA stopped producing the theremin, but the 500 units that had been sold up until 1931 had created a market - although certainly not as massive as most had envisioned. All over the US there were amateur and professional thereminists; *The New York Times's Classified Ad* and *Public Notices* sections featured announcements of people looking to buy and sell theremins, as well as thereminists offering their services as entertainment, generating a small scale economy around the instrument. Its regular use in movies, radio, TV shows and successful LPs retained the theremin in the imaginary of the public.

The absence of commercial manufacturers opened the door to amateurs to make their own versions of the instrument. The instrument boiled down to a schematic⁶², which the builder could appropriate and change. While engaged in its commercial venture, RCA realized that one of the pitfalls of the

⁶¹ "As Clark systematically dismantled the qualities that made the theremin unique, he essentially wound up with an electronic organ and discovered in the process that the American public leaned toward conventional electronic keyboard instruments. These kinds of devices were growing in popularity anyway, and they began to point the way for commercial success in the field of home electronic musical instruments. Clark, perhaps without fully realizing it, had begun to sound the death knell for the RCA Theremin" [9].

⁶² A diagram that specifies the parts, and connections between these parts, to make up an electronic circuit, therefore allowing for its reproduction.

instrument was that it could malfunction and need repairs and faced the fact that it relied on a set of un-trained salesmen to do it. The RCA-Theremin “Service Notes” contained diagrams and schematics of the instrument as people often had to repair it themselves[31]. The theremin thus joined the growing world of amateur electronics and the culture of *Do It Yourself* or DIY.

As early as 1928, schematics were published in *La France Radiophonique*[6] and in the theremin patent itself[63]. In the *Berlin Wireless Exhibition* of 1932, an organization called the Heinrich Hertz Institute, exhibited an instrument “based largely on that of Theremin”⁶³ and taught “interested amateurs how they [could] build them for themselves”[55].

In the US, schematics and tutorials were occasionally published in electronics magazines⁶⁴[8],[12], including a 1949 article by Ernest J. Schultz[36] used by Robert Moog to build his first theremin, and a 1954 article by Moog published in *Radio and Television News*[24] with his own version of the instrument. At this time, Moog became a small-scale theremin builder, hand-building each unit upon order and offering the first commercial model in 15 years[27]. Moog began to improve the theremin and offered a few different models, some of which included an “overtone selector” and a “synthetic formant”.

6.3 The Schematic

The fact that Moog was able to access information, improve a design, produce information and submit it to a larger community was not a minor achievement, but perhaps the most important - yet involuntary - contribution Theremin ever did to electronic and computer music as a discipline. It marked the beginning of a new paradigm in the exchange of information regarding sound production.

Moog’s access and appropriation of information was not that different from Theremin’s access and appropriation of patents and discoveries like that of De Forest’s *Audion*. Notwithstanding the great merit and vision of Theremin’s work, this work was primarily one of combining or interconnecting electric components, concepts and ideas, and experimenting. Theremin’s

⁶³The difference being that this one used a pedal for amplitude control instead of the left hand.

⁶⁴A tradition still very much alive in <http://www.thereminworld.com>.

various interfaces for the same sound production device; of the same interface to control sound, or light, or color; indicated not only an unprecedented flexibility in designing the relationship between gesture, effort, power, sound, and so on, but prefigured the concept of modular design. While it wasn't actually modular in design, Theremin's ability to re-wire his inventions revealed that any voltage could potentially control any other voltage; any device could control any other device.

The degree to which the idea of modular design is indebted to the theremin is hard to assess. However, that one of the main forces behind this design philosophy (Moog), began his work as a theremin builder cannot be ignored. Buchla, another driving force behind the idea of voltage controlled synthesizers, offered a *Model 117* module called "Dual Proximity Sensor", offered with theremin-style antennas[3], enabling the user to patch a theremin by combining it with other modules. The theremin was a circuit with one configuration, or in other words, a hard-wired voltage-controlled synthesizer.

The schematic, a symbolic and graphical representation of an electric circuit, converted the instrument into a code for information exchange. As such, it opened up the possibility of re-constructing the theremin, but more importantly, of modifying it and/or recombining it - fully or in parts - with other electric devices; in short, it allowed for (0) the exact replication of the instrument, (1) its study, (2) its partial appropriation, using a part of the circuit with a different purpose or in a different context, (3) its complete appropriation, using the whole device as part of a larger context, and (4) to convert these processes into a schematic too, further advancing the exchange of knowledge and information.

7 Conclusions: The *message* of the theremin

The theremin attracted the attention of the world because of the magical qualities of its invisible, intangible interface. These qualities situated it at the forefront of the wave of scientific and technological innovation that dominated the era. The romantic repertoire, soloist status, and the venues of the musical establishment, all became contributing factors that legitimized the technological apparatus as a musical instrument. The combination of scientific and technological innovation, and of musical tradition made the theremin a perfect point of departure for speculation about the "music of the future".

While legitimized as a musical instrument in the eyes of the press, the theremin posed several challenges to the traditional concept of musical instrument: instead of a fixed timbral identity, the theremin offered infinite timbres including - and superseding - those of mechanical instruments. The ideal or universal musical instrument capable of all timbres, with an infinite pitch range, and a sound purer and more powerful than that of any other instrument, was construed as a medium that overcame the limitations of the physical world. At the same time, the theremin was construed as a direct, transparent and immediate instrument, capable of translating faithfully the performer's personality - and even his thoughts - into sound without getting in the way. In consequence, the theremin seemed to reach the ideal where nothing mediated between the musician and the music, becoming a non-medium - and to some extent, a non-instrument.

The dissociation of gestural energy and sound power, of the sound production device from the interface, of the qualities of the timbre from the actions of the performer, were all characteristic of electric media and introduced unprecedented flexibility in instrument design. Theremin used the same interface for different purposes - one of them being to produce sound - and different interfaces for the same sound production device. In this way, the electric medium was presented as modular: where any voltage could control any other voltage and any device could control any other device. In this way the theremin opened new paths for exploration.

But these new paths were only possible because of the imitation of mechanical instruments. This is what made the theremin such a strong medium. The popularity of the instrument and of the inventor himself became the catalysts of the changes that the theremin announced. In other words, what attracted the large audiences of the 1930's was the lure of attaining the ideals of Western music: the pure tone of the voice, the loudness that the orchestra and organ did not achieve, the instrument everyone could play, the possibility of realizing all timbres in one device, a mass market; in short, the appearance of a new medium that would match and surpass what music media had allowed until then. What they actually got was a schematic.

To use a McLuhan metaphor, the theremin's imitation of mechanical instruments was "like the juicy piece of meat carried by the burglar to distract the watch-dog of the mind" [22], while the real "message" of the theremin - the introduction of modularity as a design philosophy and of the schematic as an operable and transmittable code - sneaked in silently through the back door.

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