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1.3 Instruments Obedient to His Thought: Edgard Varèse's sound ideals and the actual capabilities of electronic resources he had access to

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Abstract

Shortly after his arrival in the USA Varèse attended a demonstration of the telharmonium, the instrument his mentor Busoni had envisaged as an answer for microtonal intervals. At about the same time he stated: "what I'm looking for are new technical means which can lead themselves to every expression of thought."

At several occasions Varèse elaborated on what those means could be, and what they should be able to produce. The present paper discusses some of the nuances of his discourse, parallels being drawn with the instruments he was acquainted with at different times: Bertrand's dynaphone, the fingerboard theremins specially commissioned for Ecuatorial and the ondes Martenot used on the 1961 version, his Ampex 401A, used to collect sound materials for Déserts and the diffusion system of the 1958 Phillips Pavillion.

The capabilities of these resources and their control interfaces are analysed from an organological perspective, and the way they relate to Varèse's sound ideals and demands is discussed, leading to the conclusion that he felt attracted towards very basic instruments with versatile interfaces.

He used a tape recorder to explore the idiosyncrasies of existing sounds, but he also composed for the Philips Pavillion, itself a musical instrument with a highly idiosyncratic spatialization system.

Keywords: Edgard Varèse; Theremin; Dynaphone; *Ecuatorial*; *Poème Electronique*

Introduction

After arriving in the USA Edgard Varèse expressed his need for new sound producing resources. From the early 1930s he tried to get a studio-laboratory, which he only succeeded for brief periods in the 1950s.

Varèse was able to overcome the lack of such resources by the way he wrote for traditional instruments. But he was also aware of the potential of a number of instruments he came across. It is the object of this paper to discuss the sound producing and controlling capabilities of these instruments, and the way they relate to Varèse's own ideas on *organized sound*.

Varèse's Ideals

While in Berlin (1907–1915) Varèse was influenced by Ferruccio Busoni, whose *Sketch for a New Esthetic of Music* [1] he considered "a milestone" in his own musical development, stating:

> … when I came upon "music is born free; and to win freedom is its destiny," it was like hearing the echo of my own thoughts. (E. Varèse, 1966, p. 73)

This yearning for freedom is ubiquous in Varèse's thought, together with his quest for new resources. In March 1916 he declared:

> New instruments must be able to lend [themselves to] varied combinations and must not simply remind us of things heard time and time again. Instruments, after all, must only be temporary means of expression. Musicians must take up this question in deep earnest with the help of machinery specialists. In my own work I have always felt the need for new mediums of expression. I refuse to limit myself to sounds that have already been heard. What I am looking for is new mechanical mediums which will lend themselves to every expression of thought and keep up with thought. (E. Varèse, 1916a)

In May 1917 he proposed:

> Notre alphabet est pauvre et illogique. La musique ... a besoin de nouveaux moyens d'expression et la science seule peut lui infuser une sève adolescente.
> Pourquoi futuristes italiens reproduisez-vous servilement la trépidation de notre vie quotidienne en ce qu'elle n'a que de superficiel et de gènant?
> Je rève les instruments obéissants à la pensée—et qui avec l'apport d'une floraison de timbres insoupçonnés se prétent aux combinations qu'il me plaira de leur imposer et se plient a l'éxigence de mon rythme intérieur. (E. Varèse, 1917)

These texts present a rich and dense line of thought, a core of ideas Varèse would elaborate upon over time. Schematically:

1. Musical alphabet:
   a) must be enriched [1916];
   b) is poor and illogical [1917];
2. No point in:
   a) being limited by sounds already heard [1916];
   b) reproducing "the superficial and annoying of daily life" [1917].
3. Instruments must be only "temporary means of expression" [1916], a practical solution while a more direct bridge between composer and listener is not found.
4. New mediums / instruments must:
   a) allow every expression of thought [1916]; be obedient to the thought [1917];
   b) lend themselves to combinations;
   c) originate a wealth of "unsuspected timbres" [1917].
5. The answer lies in:
   a) "mechanical mediums," collaboration between musician and "machinery specialists" [1916];
   b) science [1917].

Earning the musician more freedom is implied in the identification of current limitations (1, 2a, 3), the need of extended sound producing capabilities, such as new, unknown timbres (4c), and the composer's degree of

control (4a). The media allowing "every expression of thought" of 1916, stressing an unlimited range of sound results, become "instruments obedient to the thought" in 1917, emphasizing control given to the composer, which implies an accurate and responsive interface, ideally dispensing with the performer altogether (3).

Concerning the technical implementation of the new resources, while in 1917 he referred broadly to "science" as providing the answer, in 1916 he specified "mechanical mediums" and "machinery specialists." Variants of this idea are also found in a letter from 26-03-1916, where he wrote to his former mother-in-law, Mrs Kaufmann:

> I'm looking into the question of getting new electrical instruments made of my own invention. (L. Varèse, 1972, p. 122)

And in a 1922 newspaper interview:

> What we want is an instrument that will give us continuous sound at any pitch. The composer and electrician will have to labour together to get it. (E. Varèse, 1922)

The word "electronics" had not yet come into general use, but the concept was beginning to emerge. Electronics is related with active components, the earliest ones being three-electrode valves. These devices had amplification capabilities, and their nonlinear transfer function allowed it to produce sustained electric oscillations. "Continuous sound" was thus within reach, although a suitable interface would be necessary to get it "at any pitch."

Electronics became more visible just after WW1: in May 1919, during the *Victory Liberty Loan*, "112 loud-speaking telephone receivers" were suspended over Victory Way, and in the following years similar public address systems were employed in othre civic events in New York. (Bento, 2005: p. 22-24)

References to the electrician by Varèse may thus indiciate awareness of the potential of whatever resources he came across.

Cahill's Telharmonium

In Berlin, Varèse learned from Busoni about an "electrical" instrument, which he saw "demonstrated in New York and was disappointed." (E. Varèse, 1966, p. 74) This instrument was the telharmonium, pattented by Thaddeus Cahill as an "apparatus for generating and distributing music electrically." (Cahill, 1915) It produced electrical signals sent through telephone lines, but no means were available then for amplifying those signals, requiring strong electrical currents to be produced. The result was a cumbersome and expensive instrument.

The basis of the telharmonium was a set of rotating shafts moving at constant speeds, proportional to the frequencies of the notes in equal temperament. Those speeds were obtained from a master shaft through a set of belts or gears. Frequency ratios between notes were thus fixed at the building stage.

Each note had a number of alternators with a different number of poles, producing frequencies *n* times the rotation frequency of the corresponding shaft. Near sinusoidal currents were available for the exact harmonics of each note and its octaves. Mixing them allowed complex, continuous periodic signals with a given strength for each harmonic to be generated.

Three telharmoniums were actually built:

1. a small working model (1898) (Weidenaar, 1995, p. 34);

2. a much larger instrument put to commercial use from 26-09-1906 to 16-02-1908, when financial difficulties let to its dismissal (*ibid.*, p. 53, 82, 121, 222, 245);

3. A downsized instrument, built in Holyoke (NJ), first demonstrated in 09-04-1910 (*ibid.*, p. 232) and moved to New York in 1911, where its premises were built on wet soil, creating a number of technical problems. (*ibid.*, p. 245)

Cahill's company went bankrupt in 1914, but the third telharmonium probably lingered there to about 1918. (*ibid.*, p. 246, 253, 255) The demonstration Varèse attended must have been of an instrument in deplorable condition, not least because of the dampness of the place.

Varèse's expectations were certainly influenced by Busoni's perception of the telharmonium. On 16-07-1906, the latter had written to Vianna da Motta that he just heard of:

> … a "perfect" musical instrument, which sounds are produced by electrical currents regulated according to the number of vibrations ... for each sound there is a device that provides the fundamental note, another the first overtone, a third the second—and so on —; then you may 'regulate', as you like, the number—the volume of the overtones and the relations among themselves, such combinations being apparently unlimited. (Beirão, Beirão & Archer, 2003, p. 42)

In his *Entwurf ...*, Busoni references a 1906 article by Ray Stannard Baker (Baker, 1906), who states Cahill's idea was:

> … to construct a machine which would give the player *absolute control of the tones produced* … a perfect instrument, giving as he says "a sustained tone controlled by the touch" … suppose he could mold that tone under his hands as a potter molds clay … the player has unlimited volume at his instant command (*ibid.*, p. 298)

The ideas of moulding a continuous sound and of "unlimited volume" are very close to the way Varèse would compose later. Moreover, the telharmonium had not only pedals for continuous volume control, but also a "dynamic manual," by which "the loudness of the notes can be increased or decreased by greater or lesser steps as required, and with absolute instantaneousness." (Cahill, 1915, p. 22*f*).

Busoni's presents the telharmonium as a solution to produce sounds in his microtonal alternative to equal temperament, describing it as:

> ...einem umfangreichen Apparat ...welcher es ermöglicht, einen elektrischen Strom in eine genau berechnete, unalterable Anzahl Schwingungen zu verwandeln. Da die Tonhöhe von der Zahl der Schwingungen abhängt und der Apparat auf jede gewünschte Zahl zu 'stellen' ist, so ist durch diesen die unendliche Abstufung der Oktave einfach das Werk eines Hebels, der mit dem Zeiger eines Quadranten korrespondiert. (Busoni, 1916, p. 44-45)

Busoni must have misunderstood something: the telharmonium never had any dials controling the frequencies of individual notes. Perhaps he imagined

such dials as the way to regulate the "number of vibrations."

Cahill was a champion of just tuning, and for the second telharmonium he developed a keyboard where one manual sounded equally tempered notes, while the one below produced a slightly flat and the one above slightly sharp versions of some notes, allowing chords with thirds in just tuning to be used. A fourth manual gave very flat versions of some notes, tuned as true 7th harmonics for dominant seventh chords. (Weidenaar, 1995, p. 63)

This keyboard was also nonstandard because there was a black key between every two white keys, rather than the standard 2+3 pattern. It was develped with the help of Edwin Hall Pierce (Weienaar, 1994, p. 60*f*), a performer who also had the task "to devise a practical system of fingering … and to solve the problem of correctly indicating … the manner in which music was to be rendered in just intonation." (Pierce, 1924, p. 328) Pierce's connection with the telharmonium lasted until early 1907. Later he wrote:

> The younger players whom I taught ... at first followed out my instructions in regard to intonation, but as time went on they ... relapsed more and more into the modern tempered scale. (*ibid.*, 1924, p. 330)

The third telharmonium had a standard double manual keyboard with a 2+3 pattern (Weidenaar, 1995, p. 235), and although Cahill still found a way to play in just tuning this must have been very limited. Also, while the second telharmonium had 18 alternators per note, there were only 11~12 (*ibid.,* p. 99, 233) on the third, resulting in a compass of around five octaves [2].

The wide compass and possibilities of experimenting with small differences in pitch were thus no longer available in the instrument seen by Varèse. Nothing of the dials imagined by Busoni, and no way to use but predifined frequencies. It could provide "continuous sound," but not "at any pitch."

Varèse's visit to the telharmonium, his requirement for "mechanical media" and his reference to "electrical instruments" of his own invention must have occurred at about the same time, although the exact sequence of events is not clear. Was he in anticipation of seeing the telharmonium and just dreaming of having custom-made instruments for himself? Had he seen the instrument and, although disappointed, was considering possible variations, more suitable to his purposes?

A Clearer Definition of Varèse's Sound Targets

In a 1930 interview Varèse gives some cues about the sound results he wanted to achieve:

> Le système temperé actuel me parait périmé ... de nouveaux moyens nous offrent une spéculation illimitée sur les lois de l'acoustique et de la logique ...
> Les instruments que les ingénieurs doivent mettre au point avec la collaboration des musiciens, permettront l'emploi de tous les sons ... Ils pourront reproduire tous les sons existants et collaborer à la création de timbres nouveaux ... Adaptés à l'acoustique des salles actuelles, ils pouront être doués d'une énergie illimitée ... Prenant en masse les éléments sonores, il y a des possibilités de subdivision par rapport à cette masse: celle-ci se divisant en d'autres masses, en d'autres volumes, en d'autres plans, ceci de par des diffuseurs disposés en des lieux différents, donnant un sens de mouvement dans l'espace ...
> Dans le grave ... nous sommes presque arrivés au maximum de ce que l'organisme humain peut enregister ... au sujet du pouvoir d'enregistement de hautes fréquences par les oreilles moyennes ... je croix qu'on pourrait se baser sur une moyenne de 18 000 en toute sûreté, et ajouter aux limites des instruments d'aujourd'hui au moins 2 octaves ...
> Une chose que je désirerais voir se réaliser est la création des Laboratoires acoustiques où compositeurs et physiciens collaboreraient ... On n'a pas, jusqu'ici, assez considéré le problème des sons résultants inférieurs: a) sons differentiels ... b) sons additionels. (E. Varèse *et al.*, 1930, p. 123, 125-126, 128)

The main ideas are:

1. Freedom from equal temperament;

2. The ability to create new timbres;

3. Unlimited dynamics (namey in the *fff* side);

4. Diffusion of sound to different points in space through loudspeakers;

5. Expansion of higher pitches up to 18,000 Hz;

6. Physicists and musicians collaborating in laboratories;

7. Exploring difference and sum heterodyne components.

Using loudspeakers as a means to spatialize sound may have been suggested by the aforementioned public events in New York. Varèse had plans to use such resources on his unfinished project *The one all alone*. In 1931, Alejo Carpentier, who was to write its text based on an original idea from Varèse, revealed that it was intended to use "several ondes Martenot" and exploit "every possibility offered by the use of electricity on stage, with superimposed planes." His description of the action includes the following passage:

> The hour of dawn arrives, and the sun does not appear. Loudspeakers situated on different parts of the stage, and in the auditorium, announce that "the sun has not been seen anywhere on the planet [3]."

Varèse imagined the bass part of *Ecuatorial* for Fyodor Chaliapin, who had a very powerful voice. For the première (15-04-1934) another singer was engaged instead who, according to Slonimsky (Slonimsky, 1983, p. 211), he "almost disintegrated when confronted with the sound of the theremin." A hand-held megaphone had to be used. (MacDonald, 2003, p. 265)

The reason here was getting the proper dynamic level, but on 06-12-1936 an article appeared in *The New York Times* under the title "Varese Envisions 'Space' Symphonies: Says Orchestra Music of the Future Will Be Re-Blended by Scattered Amplifiers." The idea of spatialization through loudspeakers would have its ultimate materialization in 1958 with *Poème Electronique* — where, as in *Ecuatorial*, very high frequencies are in evidence.

Varèse's aims are also clarified in a letter dated 06-02-1933 to the Guggenheim Foundation:

> The acoustical work which I have undertaken and which I hope to continue in collaboration with René Bertrand consists of experiments which I have suggested on his invention, the Dynaphone ... the technical results I look for are as follows:
> 1 To obtain absolutely pure fundamentals.

> 2 By means of loading the fundamentals with certain series of harmonics to obtain timbres which will produce new sounds.
> 3 To speculate on the new sounds that the combination of two or more interfering Dynaphones would give if combined in a single instrument.
> 4 To increase the range of the instrument so as to obtain high frequencies which no other instrument can give, together with adequate intensity.
> The practical result of our work will be a new instrument which will be adequate to the needs of the creative musician and musicologist. I have conceived a system by which the instrument may be used not only for the tempered and natural scales, but one which also allows for the accurate production of any number of frequencies and consequently is able to produce any interval or any subdivision required by the ancient or exotic modes [4].

His requirements are consistent with the 1930 interview, but now he speaks of "absoloutely pure fundamentals" and "loading" them with "certain series of harmonics." He also speaks of nonstandard tunings.

Bertrand's Dynaphone

Given the importance attributed by Varèse to the Dynaphone, it is most vexing that so little is known about it. One photo (L. Varèse, 1972, p. 146-147) shows two half-cilyndrical boxes with a hand-controlled dial moving on a half-disc shaped quadrant, some 30 cm in diameter. Photo details of the dial and quadrant are presented in an article by Dermée, who states he is not able to explain its principle because Bertrand "l'a couvert par un brevet provisoire et il n'a cure qu'on lui enlève le bénéfice de son invention," but that it produces "oscillations … directement audibles," (Dermée, 1928) implying it was based on an audio oscillator. According to Givelet, the apparatus consists on a single vacuum tube oscillating circuit comprising "une forte self-inductance à noyau de fer, et un condensateur tournant [*i.e.*, variable]," adding that several intermediate endings of the inductance would be used to extend to different octaves. (Givelet, 1928, p. 276) Dermée specifies a five octave range for a single instrument, two instruments being able to cover over seven octaves, and states that the frequency may range from "une période à près de 12.000 par seconde " (Dermée, 1928)—Varèse's "high frequencies which no other instrument can give." There is also a reference to levers allowing to vary "la puissance du son et aussi le timbre par l'adjonction d'harmoniques." (B., 1928). , p. 43)

Bertrand's brevet (Bertrand, 1928) has the title "Commande d'appareils de musique à ondes électriques" and it does not specify any concrete electronic circuit. His oscillators must have been fairly standard. The invention itself is defined as a generic control device, being able to act upon different components of an oscillator:

> ... un levier dont les déplacements angulaires règlent la capacité d'un condensateur ou la valeur de la self-induction d'une bobine ou l'intensité du courrant du chauffage de lampe, ce levier étant solidaire d'un index se déplacant devant un cadran en indicant ainsi la note émise par l'appareil. (*ibid.*, p. 1)

A small switch on the lever allowed the sound to be discontinued, in order to separate one note from the next; but the nature of the interface made glissandi particularly easy to obtain.

Bertrand was engaged in giving the player as much ease and accuracy of control as possible. He stated the lever should be long enough for its axe to be turned "sans effort appréciable," and suggested the use of a spring so it could be moved with a single finger. (*ibid.*, p. 2) For a five octave range, a diameter of some 30 cm means 7~8 mm for each semitone: not a lot, but still enough to allow for some microtonal experimenting.

The instrument had the standard note locations marked in it, but a removable quadrant could be superposed, with the location of the successive pitches to be played previously marked. (*ibid.*, p. 2) Such a graphic interface would make it easy for the composer to deal with pitches as frequencies, independently of any preexisting system. It also reminds us of Varèse's remarks in 1936:

> I am sure that the time will come when the composer, after he has graphically realized his score, will see this score automatically put on a machine that will faithfully transmit the musical content to the listener ... The new notation will probably be seismographic [5].

The dynaphone is thus a signal generator with a simple but effective interface, much in accordance with Varèse's needs in the early 1930s. It was invented in 1927, but Varèse first met Bertrand in May 1913. (MacDonald, 2003, p. 6) Could it be that they talked about the dials imagined by Busoni?

Ecuatorial, the Theremin Instruments and the Ondes Martenot

Dynaphones were unavailable to Varèse when he returned to New York in 1933. At this time, Lev Termen was producing electronic instruments based, on the heterodyne principle, where an audio oscillation was obtained through interference between two radio-frequency oscillators, one of a fixed frequency, the other subject to variation according to the capacitance of the player's right hand as it approached a vertical antenna. Pitch could thus be freely controlled by right hand movements. A second antenna, horizontal and loop-shaped, allowed the left hand to control dynamics.

Termen also produced *fingerboard* or *cello-theremins*, based on a similar principle but with a different interface: pitch was controlled by pressing a plastic tape at different places, while the weight of the right hand on a spring-loaded lever controlled the amplitude. The visual effect was not as dramatic as in the space-controlled theremin, but physical contact with the instrument provided a better control. This might have pleased Varèse, who on 14-10-1933 wrote to Jolivet:

> J'ai trouvé le laboratoire—et ce qu'il me faut pour mes nouveaux instruments… nous sommes avec Thérenin [sic]—qui a un magnifique Laboratoire—en plein travail pour mes nouveaux instruments. (Varèse & Jolivet, 2002, p. 63, 65)

Termen often made instruments by special order [6], and for *Ecuatorial* two fingerboard theremins were comissioned on Varèse's specifications, with a very high upper frequency limit, which in 20-02-1959 Varèse quoted as 12,544.2 Hz [7]—about the same as on the dynaphone. In 09-11-1958, however, he gave 6,000 Hz as the highest frequency [8].

Could Varèse be trying to get a dynaphone clone? And did the comissioned instruments really attained that specification? At this time loudspeakers were large and of the full range type, so 6,000 Hz might have been a practical limit. This is still above e'''' (5,274 Hz), the highest note on the 1961 score of *Ecuatorial* [48], where Varèse used a pair of *ondes Martenot*, instead of the theremins.

Was this replacement a matter of necessity rather than choice? Varèse seems to have been quite happy with the instruments by Termen, whom he tried in vain to reach in a letter dated 05-05-1941:

> I have just begun a work [where] I want to use several of your instruments—augmenting their range as in those I used for my Equatorial—especially in the high range. Would you be so kind as to let me know if it is possible to procure these and where ... (Varèse, 1961)

The *ondes* use the same hetherodyne principle as the theremin, but with a *luthier* rather than an engineer's approach. Attached to a string, a ring is placed on the player's index finger, and its movement left and right controls pitch, while a pressure sensitive key allows the left hand to control dynamics and mould amplitude envelopes. Further left hand commands change the waveform and switch between differently sounding louspeakers.

Varèse was familiar with the *ondes*. He attended the New York première of Jolivet's *Concerto* (09-11-1949), which he thought "admirablement présenté." (Varèse & Jolivet, 2002, p. 178) The *ondes* part was played by Martenot's sister Ginette, who on 15-11-1949 visited Varèse. (*ibid.*, p. 178, 180)

The 1961 score does not explore the timbre modifying possibilities of the left hand controls. It should be playable on either dynaphones or the original theremins, but no text by Varèse seems to exist expressing the same degree of yearning for the *ondes* as for those instruments.

The *ondes* parts have constant crescendos and diminuendos modulating long notes, and dynamic levels from *pppp* to *ffff* (plus *fp* and *sffp*). Their compass is B-e'''' (117-5,274 Hz), with pitches below g' (396 Hz) mostly doubling the voice. Higher frequencies dominate. On the organ part, if a 32' register is available [9], frequencies as low as 16 Hz will be produced. An unusually wide spectrum is thus explored.

Since the largest organ pipes usually alternate between the left and right side of the console, spatial effects may result. Also, the use of very high frequency sounds with changing dynamics may originate subjective illusions of movement, since our directional perception depends on the selective behaviour of our *pinna* for these frequencies.

What Varèse apparently required for the theremin / ondes parts was thus a means of providing continuous sounds up to very high frequencies, with the possibility of progressing by glissando, and the ability to constantly modulate their intensity with great precision and through a wide dynamic range.

Tape Recording and Spatialization: The Ampex 403A, *Déserts* and the *Poème Electronique*

From 22-03-1952 Varèse owned a tape recorder with accessories (MacDonald, 2003, p. 329, 338), an Ampex 401A portable single-track model, with a frequency response of 30-15,000 Hz (±2 dB) at the highest of two speeds (7.5 and 15 ips) and an input allowing to feed the syncronous motor from an external oscillator. (Ampex, 1953)

The Ampex was used to collect material for *Déserts*, but although a single-track would allow easy tape reversing and collage work, very little further experimenting could have been done without further equipment, and no spatial effects were possible. The Club d'Éssai allowed him to complete the interpolations for the 1954 première, where the interpolations were diffused in stereo, and in 1961 he revised them at the Columbia-Princeton Electronic Music Centre. (Ussachevsky & Bayly, 1982/83, p. 149-150)

In 1936 Varèse spoke of a new dimension in music:

> ... sound projection—that feeling that sound is leaving us with no hope of being reflected back, a feeling akin to that aroused by beams of light sent forth by a powerful searchlight—for the ear as for the eye ... [10]

While the term has a metaphorical or synaesthesical use here, in 1959 Varèse said of *Poème* Elecronique [11]: "For the first time I heard my music literally projected into space [12]." Composed for the 1958 Brussels World Fair Philips Pavilion, it was diffused through Philips 9710M loudspeakers, which had a very wide frequency response with a substantial emphasis between 2,200 and 15,000 Hz, quite adequate for Varèse's taste for higher frequencies.

The Philips Pavilion was shaped like a three-peaked tent, the loudspeakers being placed on the inside of its curved surfaces in two ways:

1. sound routes, where a track is successively routed to new loudspeakers in a row, so the sound source appears to have a linear movement;

2. loudspeaker groups, where sounds can be sent to specific points.

Sounds could rotate around the public, move vertically, or even change from a horizontal to a vertical movement along the way. Loudspeaker groups placement allowed sounds to be bounced either horizontally or vertically. (Bento, 2005, p. 136-138)

Three single track and one stereo magnetic tapes were combined at the final stage on a three track tape. A second, synchronized tape contained control signals, routing each track to a specific loudspeaker group, or through a sound route at a given rate.

Varèse worked in an improvised studio on a large empty pavilion, and some loudspeaker rows were placed along its walls, in order to allow some experimenting with horizontal sound routes (*ibid.*, p. 139) [13]. According to Willem Tak, who assisted the composer:

> Varèse concentrated primarily on the character of the tonal pattern, and for the most part left us to decide the "intonation" (the distribution of sound over the loudspeakers). (Tak, 1958/59, p.43)

Perhaps projecting individual sound masses differently into space was more important for Varèse than their exact spatialization. Or he might need to experience the effects *in situ* to apreciate the possibilities given by the highly idiosyncratic nature of the spatialization system itself, in which case his role here would only become visible at a final stage.

The inner wall surfaces of the Philips Pavillion were covered with asbestos, creating a very dry acoustics. (Bento, 2005, p. 124-128). As Tak put it, "the space ... was to seem at one moment to be narrow and dry, and at another to seem like a cathedral" (Tak, 1958/59, p.43)—another way of creating spatial suggestions in music which Varèse explored.

A Final Note

The instruments and resources which Varèse came across seem to have stimulated his thoughts on how to develop in specific ways the general aesthetic ideals of freedom of expression inherited from Busoni. By the mid 1930s, Varèse's ideas had evolved into a solid and consistent discourse, incorporating the idea of sound masses moving in space, either metaphorically or literally.

Varèse demanded absolute control over sound and no limits on the available materials. He wanted to deal with *pitch*, traditionally based on discrete values, as *frequency*, a continuous variable, and he particularly liked to explore the extreme treble. He required flexibility in modulating the amplitude and was keen on exploring dynamic levels from the barely audible to the deafening strong.

His enthusiasm towards the dynaphone and fingerboard theremin stems from the liberty of pitch and dynamics afforded by their simple interfaces.

Notes

[1] First published in 1907, enlarged German edition in 1916. Varèse acquired in the USA the 1911 English translation (Busoni, 1911).

[2] Assuming the 3rd and 5th harmonics were produced for every note.

[3] "Edgard Varèse Escribe Para El Teatro". *Sócial*, vol. 14, no. 4 (April 1931). Quoted from (MacDonald, 2003, p. 227-228).

[4] Letter to Henry Allen Moe, of the Guggenheim Foundation, dated 06-02-1933. Quoted from (Manning, 1993, p. 9).

[5] Conference in Santa Fe, 23-08-1936. Quoted from (Schwartz & Childs, 1998, p. 198).

[6] A fingerboard instrument producing particularly low frequencies, served by a huge loudspeaker, was commissioned by Leopold Stokowski to reinforce the basses of the Philadelphia Orchestra (Glinsky, 2000, p. 109-111, figure between p. 202 and 203).

[7] Conference at Sarah Lawrence College on 20-02-1959, quoted from (Schwartz & Childs, 1998, p. 206). There may be some mistake in this number: For a'=440 Hz, g''''' = 12544.85395, which would never round to 12544.2.

[8] Conference at The Village Gate Café (09-11-1958), quoted from (Mattis, 1992, p. 50).

[9] Both the 1934 and the 1961 presentations were at New York's Town Hall, where a 32' register based on difference tones was introduced in 1935 in the organ, which had nothing larger than 16' before.

[10] Conference in Mary Austin House, Santa Fe, 23-08-1936, quoted from (Schwartz & Childs, 1998, p. 197).

[11] Only the sound part of this multimedia project is discussed here. For its other dimensions see (Treib, 1996).

[12] Lecture at Sarah Laurence College, 1959 (Schwartz & Childs, 1998, p. 207).

[13] Also, reverberation times would have been much higher than in the Pavillion.

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