Curatorial > PROBES

In this section, RWM continues its line of programmes devoted to exploring the complex map of sound art from different points of view, organised into curatorial series.

Curated by Chris Cutler, PROBES takes Marshall McLuhan's conceptual contrapositions as a starting point to analyse and expose the search for a new sonic language made urgent after the collapse of tonality in the twentieth century. The series looks at the many probes and experiments that were launched in the last century in search of new musical resources, and a new aesthetic; for ways to make music adequate to a world transformed by disorientating technologies.

Curated by Chris Cutler

PDF Contents:

At the start of the seventies, Chris Cutler co-founded The Ottawa Music Company – a 22-piece Rock composer's orchestra – before joining British experimental group Henry Cow, with whom he toured, recorded and worked in dance and theatre projects for the next eight years. Subsequently he co-founded a series of mixed national groups: Art Bears, News from Babel, Cassiber, The (ec) Nudes, p53 and The Science Group, and was a permanent member of American bands Pere Ubu, Hail and The Wooden Birds. Outside a succession of special projects for stage, theatre, film and radio he still works consistently in successive projects with Fred Frith, Zeena Parkins, Jon Rose, Tim Hodgkinson, David Thomas, Peter Blegvad, Daan Vandewalle, Ikue Mori, Lotte Anker, Stevan Tickmayer, Annie Gosfield and spectralists Iancu Dumitrescu and Ana Maria Avram. He is a permanent member of The Bad Boys (Cage, Stockhausen, Fluxus &c.) The Artaud Beats and The Artbears Songbook, and turns up with the usual suspects in all the usual improvising contexts. As a soloist he has toured the world with his extended, electrified, kit.

Adjacent projects include commissioned works for radio, various live movie soundtracks, *Signe de Trois* for surround-sound projection, the daily year-long soundscape series *Out of the Blue Radio* for Resonance FM, and p53 for Orchestra and Soloists.

He also founded and runs the independent label ReR Megacorp and the art distribution service Gallery and Academic and is author of the theoretical collection File Under Popular – as well as of numerous articles and papers published in 16 languages.www.ccutler.com/ccutler

PROBES #33

In the late nineteenth century two facts conspired to change the face of music: the collapse of common-practice tonality (which overturned the certainties underpinning the world of art music), and the invention of a revolutionary new form of memory, sound recording (which redefined and greatly empowered the world of popular music). A tidal wave of probes and experiments into new musical resources and new organisational practices ploughed through both disciplines, bringing parts of each onto shared terrain before rolling on to underpin a new aesthetics able to follow sound and its manipulations beyond the narrow confines of 'music'. This series tries analytically to trace and explain these developments, and to show how, and why, both musical and post-musical genres take the forms they do. In PROBES #33 we begin to trace the impact of the application of electricity on the world of music and look more closely at the Musical Telegraph, the two-hundred-ton Telharmonium (a 19th century mechanical synthesizer) in America, as well as the Theremin and the visionary Rhythmicon in the USSR.

01. Transcript. Studio version

[Gregorio Paniagua, 'Anakrousis', 1978]

So far in this series we have concerned ourselves with the modification of forms and behaviors within what we might call a natural acoustic ecology.[1] That's an ecology in which combinations of the specific properties of materials and the physical limits of kinetic action adapt to fill the available niches provided by an ecosphere bounded by the materiality of resonant space and the mechanics of the human ear. This is a closed system which for at least the last 44,000 years – I'm dating this from the first intimations of human culture – has encompassed the entirety of our understanding of what music was – is – or could become. It a system entirely constrained by the insurmountable fact that the only way to create a sound is to cause – by way of a physical action – either air, or some resonant material object, to vibrate.

[Orchestra tuning]

Now, the parameters within which such a sound – once it's been made – can be directed toward some communicative or aesthetic purpose, such as music – depend entirely on our having an internalized grasp of the way in which a particular configuration of materials (let's say wood, gut or horsehair) can be expected to respond to a particular directed action (let's say, bowing or tapping it) that's acted out in some particular space (let's say a cathedral or a cellar – or a village square).

So these I will call the primary interdependent axes of an *acoustic ecology*: Object. Action. Space.

We first learn to navigate our acoustic environment instinctively; knowledge comes to us unbidden as a practical corollary of sentience. In other words we observe, we act and we absorb. As time passes we learn to refine and objectify this knowledge through a combination of instruction, imitation and experiment. Meanwhile – and by a similar route – we also acquire *musical* skills, as we absorb the grammar and semantics of the sonic culture in which we are raised – and, for us, this is a system that encodes a kind of lexicon of affect which assigns particular meanings and emotions to particular combinations of sounds, periodicities and silences.[2]

[Ludwig van Beethoven, 'Symphony No. 5' introduction (Australian Chamber orchestra)]

And once we know that particular physical materials are capable of making a particular range of sounds and once we have understood the way these sounds


[Lev Termen plays termenvox]

respond, differently – but *reliably* differently – in a range of acoustical conditions, then we understand – at the deepest level – that the affinity between choral music, say, and echoic cathedrals, or chamber music and medium-sized drawing-rooms – is not capricious, but *structural*. And by the same token, we can see how the symphony and the institution of the orchestra are both clearly tied to the acoustical conditions of large, resonant, auditoria,

[Anton Bruckner, 'Symphony No. 4' (excerpt), 1874]

while the aesthetics and constitution of small jazz ensembles depend on their co-evolution in acoustically more intimate spaces.

[Oscar Peterson Trio 'Corcovado (Quiet Nights of Quiet Stars)' (excerpt), 1965]

And this is because, in every musical genre there's a structural mutuality between musical form and acoustical space. Even attributes we might consider to be quasi-autonomous – such as aesthetics, performance techniques or instrument design – are in fact inextricably bound into the ecological and acoustical niches in which they evolve. I might go so far as to say that – in all music before the twentieth century – form has followed acoustical affordance.

Which is how musicians and composers know that they have to avoid fast flurries of notes in highly resonant spaces – or that when ten violins are required to balance a single trombone, the price will be an unavoidable loss of clarity and precision.

[Gustav Mahler, 'Ninth Symphony' (excerpt), 1908]

And why it values sensation over the individuality and harmonic purity of earlier baroque composition. In fact, musicians learn very rapidly that it's impossible to impose any old musical idea they can dream up onto just any old acoustical space: in order to succeed in music, one has at least to know what works – and what doesn't work – in any particular kind of acoustical space.

[Arnold Schoenberg, 'Third Violin Quartet, 1st Movement' (excerpt), 1927]

And here's the same piece played in a large cathedral:

[Arnold Schoenberg, 'Third Violin Quartet, 1st Movement' (excerpt), 1927]

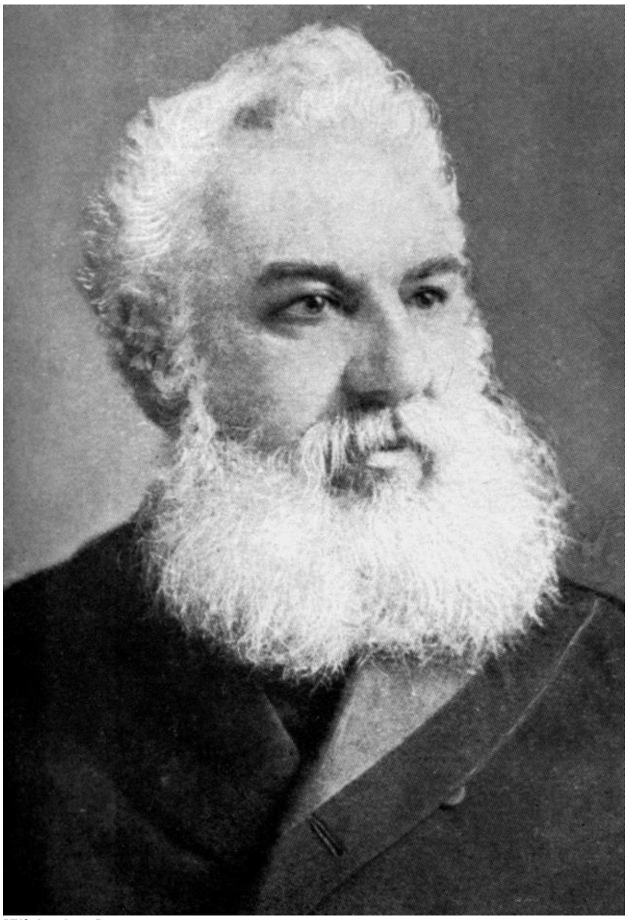
In fact, *doing what works* is one of the primary mechanisms through which all musical forms evolve. And what works in an acoustic ecology is always and entirely determined by that inescapable combination of materials, actions and spaces.

So, when the change finally came – and it was a change so unthinkable that it took decades for the reality of it to sink in – it appeared to most people as no more than a quirky sonic outrider – just one more scientific wonder in an age stuffed with wonders – when, in fact, it was the harbinger of a wholly new ecology that was answerable only to a wholly new – and revolutionary – set of affordances and laws.

Much as the ecosphere of any wild location is changed by the arrival of, for instance, wolves or beavers – which is to say, creatures that don't so much *adapt to* their environments as *reconfigure* them – so, in the musical domain, electricity proved to be similarly transformative. Both invisible and intangible, it took no account of the acoustic triad of objects, actions and spaces – which were irrelevant to its operations. In addition, by de-linking sound from both the known acoustical world and the laws that governed that world, electricity was able – indeed it was bound – to change the nature of sound itself. I know I invite skepticism here, but just stick with this idea for a moment more...

Of course electricity has always been with us – it's not something we invented – but, by the late nineteenth century, we were finally beginning not only to understand it but also, more importantly, to *control* it.

In fact, one could argue that the grand narrative of the twentieth century is inextricably bound into the story of electrification, since almost nothing has


[Elisha Gray]

escaped its transformative attentions, leading a visionary Marshall McLuhan to argue – correctly, I think – that it has changed the nature of perception itself.[3] Music, was certainly fundamentally transformed – to the degree that it would have been unrecognisable as music – even to the most avant-garde of nineteenth century composers.

[Richard Maxfield, 'Sine Music (A Swarm of Butterflies)' (excerpt), 1959]

The first unambiguous exploitation of electricity to musical effect – at least as far as I've been able to discover – was by the American inventor and engineer, Elisha Gray when, in 1874, he unveiled his Musical Telegraph. Now Grey wasn't particularly interested in music and his invention wasn't much more than an intriguing sidebar to his more immediate experiments with telephony. To an observer at the time, the means of delivery – that is to say, the transmission of sounds over great distances by way of telegraph wires – would have been what gripped the public imagination, not the next to non-existent musical content of the invention. And yet, with the Musical Telegraph, Grey established a principle that would be central to the generation of electronic sound for the next hundred and fifty years, and that's oscillation.[4] Roughly speaking this describes the creation of a feedback loop to generate a single continuous tone. In Grey's case, it was an electromagnetic current that induced a continuous oscillation in a metal reed – so this wasn't yet purely electronic oscillation, but electromechanical. The Coralcello, which we met in PROBES #5, was to use the same principle, 35 years later, to indefinitely extend the vibration of a piano string – and the same mechanism drives the contemporary e-bow.[5]

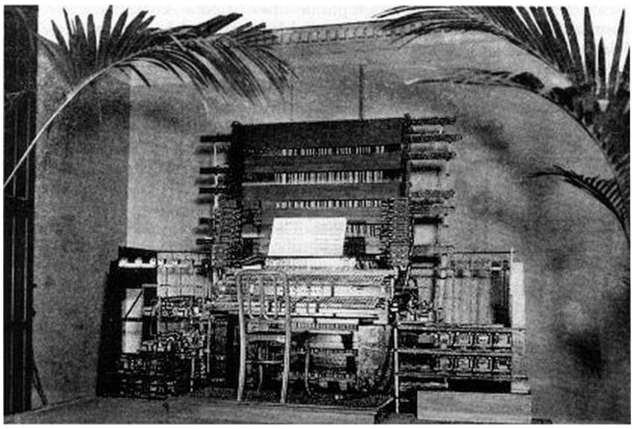
[Ebow on a bass guitar, played by Jesús Rico (excerpt), 2015]

Grey's primary goal was to demonstrate the ability of his Musical Telegraph to transmit multiple signals simultaneously, over great distances – in fact *any* kind of signals – he just used musical pitches to make his point. And yet, by linking a set of tuned oscillators to a standard keyboard, Grey had wound up designing the world's first polyphonic electro-acoustic instrument. As proof of concept, he ran a series of concerts in which performers were lodged in one city while audiences listened in another. This was an impressive achievement when you consider it predates the invention of both the telephone and radio transmission. It also predated electrical amplification, so to make the sounds audible Grey first attached specially modified metal washbasins to the receiving terminals, and later arranged a set of customized wooden tubes – a bit like organ pipes – above a grand piano whose loud pedal was weighted down, to add amplitude and colour to the tones transmitted.

Having made his point, Grey took the idea no further, but others were inspired – in particular the young Thaddeus Cahill who, 21 years later, began to work on the prototype of his now legendary Dynamophone, better known as the Telharmonium.

The Telharmonium was a jaw-dropping electromechanical behemoth weighing in at over 200 tons and costing – in today's money – more than five and a half million dollars to build. Immensely complex, it introduced polyphonic additive synthesis to the world decades before that concept came into being.[6] And this time its inventor was motivated directly by musical as much as technical ambition. Indeed he was convinced that the pure electronic tones of his Telharmonium would consign the imperfect pitches produced by conventional instruments to the scrapheap of history. With visionary chutzpah, Cahill was proposing to ignore the entire history of both sound production and instrument building and reconstruct everything from the bottom up – except this time he would avoid the pitfalls and imperfections of physically resonating objects and fallible human performers and work directly from the laws of physics. Each pitch and timbre would be constructed electronically from scratch, using a massive array of dynamos and rotors ringed with cog-like ridges. As the ridges passed a fixed point they'd induce oscillations in a magnetic field and generate pure electronic tones. And with seven sets of ridges on each rotor, mathematically spaced to generate one fundamental tone and six ascending partials, the... Comprehension malfunction. Please deploy footnote here!

[Footnote]


[The Telharmonium]

When a sound is repeated regularly, it becomes a pulse. Now, if you speed that pulse up a little by the time it gets to around 20 blips a second we start to hear it as a continuous tone with a definite pitch: Now, think of those raised ridges on Cahill's rotors. The rotor is turning, and as each ridge passes a fixed point, it disturbs the electromagnetic field and produces an electrical pulse. The closer together the ridges are, the faster the pulses they induce – and the faster thepulses, the higher the pitch.[7] And that means that by controlling the number of ridges on the rotor, and the speed of its rotation, you can control the frequency of the impulses – and therefore the pitches they generate. Now, what's interesting about all of this is that no physical action is being applied to any resonant object in order to create these sounds; they are all just pulses that reach our ears at a particular rate per second. In addition, we are hearing a single, pure frequency. That's a sound that was effectively new in the world – because, in the acoustic domain any sound you can make by causing air, or some physical object, to vibrate, will always be an untidy and complex mixture of different frequencies, all sounding together at once.

[Large gong]

Even a single string, when plucked will produce, alongside its fundamental pitch, many other pitches – which musicians call partials, or harmonics or harmonics and overtones; just single repeating wavelengths – or what musicians and physicists call sine tones. Here's Termen's own oscillator, which is still functioning and in the care of Andrey Smirnov, at the Theremin Institute in Moscow.

[Andrey Smirnov plays Theremin's oscillator in Moscow]

Well, thank you footnote, and thanks for all your footnoting over the years, I think I can say for us all that we'll be sad to see you go – and of course we wish you the best in your new job at Chapter Headings.

It's been a pleasure and I know my successor, Mr. Breadvan, will be every bit as diligent as I, when he steps into these iconic sonic shoes.

[End Footnote]

So. Now we are entering critical territory because – without going into detail – it turns out that every audible sound in the acoustical world, however complex, can in theory be broken down into – or be created out of – combinations of single frequencies at different intensities. For instance, here's an oboe playing an A.

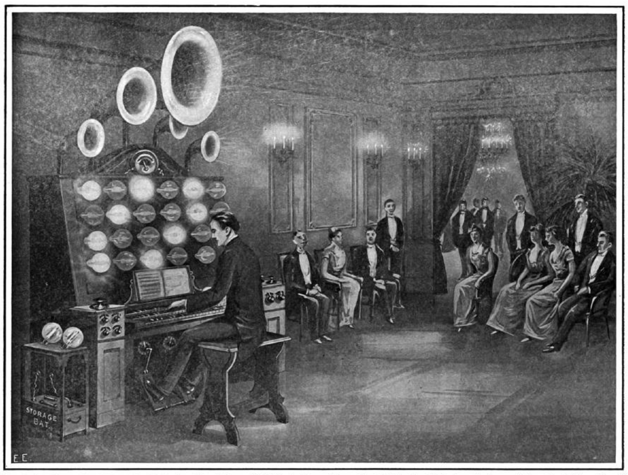
[Oboe A]

And here's a pure sine tone A.

[Sine A]

The difference is that while the pure sine tone consists of a single frequency, the oboe, which we hear as the same pitch, is made up of the fundamental – a pure sine tone – plus a complex of other accompanying harmonics that are generated by the shape and constituent materials of the instrument itself. I should add two things here: first – that every natural harmonic is a whole-number ratio of the fundamental tone and, second – that each that of these harmonics is itself a pure sine tone. This means that by combining the relevant sine tones in the right ratios, the sound of the oboe can be constructed – harmonic by harmonic – out of its parts. And this observation is true for every instrument.

Central to this understanding was Hermann Von Helmholtz's groundbreaking book, *On the Sensation of Tone,* first published in 1863. To demonstrate his discoveries, Helmholtz constructed what we now call a Helmholtz resonator – a simple acoustic device that can be used to isolate and analyse all the individual frequencies that go to make up any complex sound. In doing this, Helmholtz himself was drawing on the earlier work of Joseph Fourier who, as early as 1822, had demonstrated that any waveform – however complex – can be broken down into sinusoids – which is to say, a mathematical curve that describes a smooth periodic oscillation – in other words, a sine wave. And once you've analysed a sound into its sinusoid components, you have also generated the formula from



The Audion Piano May Entertain Us in the Near Future With Music Purer Than That Obtainable With Any Instrument Now Available. Also It Will Imitate Faithfully Any Orchestral Piece.

[The Audion Piano]

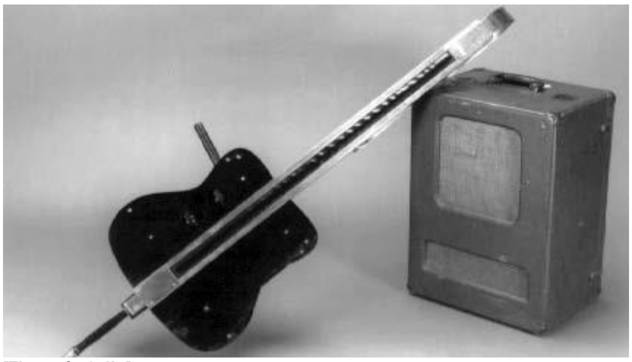
which to reconstruct that sound from scratch. And that's what Cahill did – with profound consequences. [8]

Of course, turning streams of raw sine tones into imitation instruments and then coherent musical performances was a mammoth undertaking and it took a fiendishly complex console of keyboards and controls to achieve it; but Thaddeus was up to the task and, by 1906, the Telharmonium was piping music around the city 24 hours a day, with a tag team of keyboardists supplying a constant stream of real-time music through the New York telephone network into restaurants, hotels and individual subscribers homes. Since amplifiers still didn't exist, in most cases, customized gramophone horns were attached at the end of the line to achieve sufficient audibility.Of course, the idea of a telephone subscription service wasn't new. Clément Ader's Theatrophone had been relaying live theatre and concert programmes into houses, hotels and cafes in Europe for more than eighteen years by this time – sometimes even in stereo.[9] What was different – and revolutionary – about the Telharmonium was that the sounds it transmitted were purely electronic. In fact, Cahill believed that the flawless pitches and perfect harmonies that electronic sound-generation made possible would eventually make orchestras obsolete and set music free from the crude imperfections of fallible human performers and their unreliable instruments. Not only would this new analytical purity of sound lead the world into a new era of musical appreciation, but its telephonic system of distribution would bring about the universal provision of music on demand. Unhappily, that's not how it panned out. In the continuing absence of any form of electrical amplification, the Telharmonium was obliged to generate extremely high voltages to ensure audibility – which is why it was so massive – but those voltages were increasingly creating unacceptable crosstalk with other telephone traffic – until something had to be done about it... but by then the cost of that something had become insurmountable, and, in 1910, the Telharmonium fell silent.There are no recordings, so the Telharmonic experience is another of those forever lost. Histories claim that the prototype remained in storage well into the 1950s, when Cahill's brother tried desperately to find a home for it. But, apparently, nobody wanted it and in 1962 it was sold for scrap.

[Brotherhood of Bob, 'Sic Transit Gloria Mundi']

By the 1960s, however, a whole menagerie of other instruments had emerged that were directly based on Cahill's original designs – in particular the Rangertone and the Hammond organ which, in all but name, were mini-Telharmoniums economically reconfigured for the age of amplification. But before we come to these, I have first to introduce another strand in the history electric instruments – the Audion Piano. This, like Grey's Harmonic Telegraph, was not so much musically significant as technically critical, because it introduced a third, and completely different, means of tone generation for electronic instruments – and that's heterodyning.

In 1906, the American engineer Lee de Forest patented the Grid Audion – this was the thermionic triode valve that finally made electronic amplification possible and – I think it's fair to say – formally ushered in the age of electronics. Valves lent wings to telephony and long-range broadcasting and then went on to power virtually every electronic device invented in the next seventy years, until they were finally unseated by the transistor. But it was Edwin Armstrong, another radio pioneer, and not Lee de Forest who discovered that inducing positive feedback in the Audion valve produced levels of amplification sufficient to allow radio receivers to drive loudspeakers instead of headphones. And it was Armstrong too, who discovered that, when internal feedback was increased past a certain point, the valve would begin to oscillate and produce a continuous and very high frequency tone, so high in fact as to be inaudible to the human ear. And this is where heterodyning comes into the picture. Although discovered in the electronic field by the Canadian inventor Reginald Fessenden in 1901, the phenomenon itself had long been known acoustically – most famously as the Tartini tone – named for the eighteenth violinist and composer Giuseppe Tartini, who both exploited these tones in his own work and taught the technique to his students. The idea is simple enough – even if the reality is rather complicated. It's this: when two high frequency tones that are very close together in pitch are sounded simultaneously, a psychoacoustic phenomenon – or beat frequency – is created, which we experience as a third, and much lower – tone. In fact it's a combination of the sum – and the difference between – the other two. When the original tones


[Theremin Cello]

are outside our range of hearing, then we hear only the low phantom tone. What's interesting about this is that, in the acoustic world of Tartini, this third pitch doesn't actually exist – that's to say it's undetectable with any measuring device and it doesn't cause sympathetic vibration in any other materials – it's just a psychoacoustical phantom generated between the ear and the auditory còrtex.

In the electrical world the phenomenon is slightly different, because in this ecology the generated tone, due to the complex electrical distortions and modulation is energetically as well as experientially present. Let me demonstrate. Here's professor Philippe from our PROBES research faculty: first he'll be playing two high notes on an electric guitar, with some distortion added, because that will make the low note – which he's not playing – more audible. You'll notice that as he bends one of the strings upwards, the unplayed note is bending downwards.

[Philippe Glandien, electric guitar heterodyning demonstration, guitar unfiltered]

And now the same procedure but with both high notes filtered out, so now you only hear the low heterodyne tones:

[Philippe Glandien, electric guitar heterodyning demonstration, with aggressive high cut to remove original notes]

Exploiting this phenomenon, in 1915, de Forest designed a valve-driven electronic keyboard he called the Audion Piano. Since it was built around a single triode it could only sound one note at a time – making it monophonic. But, because the triode produced electronic, rather than acoustic, data its output could be electronically rather than acoustically processed – which meant that by passing the electronic pulses through chains of capacitors and resistors, de Forest was able to produce – as he wrote at the time: 'Sounds resembling a violin, cello, woodwind, muted brass – [and] other sounds resembling nothing ever heard from an orchestra – or by the human ear – up to that time – [sounds] of the sort now often heard in [the] nerve-wracking maniacal cacophonies of a lunatic swing band. Such tones led me to dub my new instrument the Squawk-a-phone'. He also noted that: 'the Pitch of the notes... can be changed merely by putting [a] finger on certain parts of the circuit. In this way very weird and beautiful effects can easily be obtained.'

Of course, there was no niche in music for such an instrument at that time. And, in truth, the Audion Piano was – like Grey's Telegraph – more a proof of concept and demonstration of principle than a practical musical tool. Still it was a principle that would be critical to the technological evolution of electronic instruments for the next fifty years.

[Footnote]

A wry footnote here: in 1907 Cahill and de Forest briefly worked together when de Forest, hoping to interest Cahill in radio technology, used his radio transmitters to broadcast some early Telharmonium concerts. If Cahill had seen the potential of radio technology, it might have saved his project, but instead he chose to stick to the telephone, with the fatal consequences that followed.[10]

[End Footnote]

[Percy Grainger, 'Free Music No. 2' performed by Lydia Kavina, 1936 (for six Theremins)]

The first really musical application of heterodyning came out of a Soviet research institute in 1919. This was the Aetherphone or Thereminvox, introduced to the Russian public in November 1919, at what must have been a jaw-dropping concert in which its inventor, Lev *Sergeyevich* Termen – who also happened to be a conservatory-trained cellist – stood in front of a wooden box and moved his hands in the air, without touching the box at all, and somehow conjuring ethereal sounds around it that eerily matched his movements. The event was billed as science, but to the public that night it must have seemed more like magic.

Here is a snatch of Leon playing his own instrument on Russian television in 1954.


[Carolina Eyck]

[Alexandre Dubuque, 'Don't Scold Me My Dear' played by Lev Termen, 1954]

Two inaudible radio frequencies drive the theremin, one fixed, one variable. The box has two antennae. The electromagnetic fields that surround them allow the player's hand to act as the grounded plate of a variable capacitor. So that the closer the hand comes to the pitch antenna – which is mounted on top of the box – the higher the capacitance and the lower the audible frequency that's produced. And since the valve oscillations are continuous, that means the lower pitch that they induce is also continuous, meaning that as the hand moves it produces a smooth glissando from the highest to the lowest note. Whilst earlier electronic instruments had been designed to deliver fixed and stable pitches, the Theremin was designed to slide, which meant that performers had to use their ears and proprioceptive skills to articulate the notes – like violinists or cellists. A second antenna fixed to the side of the box controlled the amplitude – the nearer the hand to that, the lower the volume. And since the sound was continuous, separate pitches could only be articulated by reducing the volume between the notes. On the other hand, since the volume control was so fluidly responsive to minute movements, it could be used *expressively* – for instance, to control vibrato or dynamic modulation. So, although the Theremin was extremely one-dimensional – monophonic, monotimbral and intrinsically legato – within those confining limits, its access to expressivity through microtonal and microdynamic control, was high – and that encouraged composers to test its abilities in more conventional ensemble settings, and in doing so, grant it status as a legitimate instrument. Here's a fairly typical example taken from the Czech composer Boguslav Martinů's 1944 composition 'Fantasia for Theremin', played here by the German-Sorbian thereminist, Carolina Eyck.

[Bohuslav Martinů, 'Fantasia for Theremin' (excerpt), 1944]

Since volume and pitch were infinitely variable, the Aetherphone could deliver considerable subtlety and interactivity. Which also meant it was difficult to play well – although, if you had a good ear, you could get by pretty quickly. On the downside, you could only play one note at a time and rapid articulation was impossible. And, of course, there was no way to completely inhibit the constant portamenti – all of which made the instrument, although fascinating, quite narrow in scope. But for all that, and in spite of its many limitations, it has remained one of the only early electronic instruments still in use today. Perhaps because of its uncanny theatricality and its eerily human intonation; or perhaps because of its disarming simplicity. Certainly both the press and the public loved the theremin from start – in Russia at its launch, then in Europe when, at Stalin's behest Termen demonstrated it in Germany, France and then Britain. And finally in America where, to great anticipation, it arrived, with its inventor, in 1927.

[Ennio Morricone, 'Once Upon a Time in America', arranged for Theremin, performed by Katica Illényi (excerpt)]

The Theremin survived for other reasons too: it attracted virtuoso performers, like Lucie Bigelow and Clara Rockmore, who commissioned new works and gave high profile concerts; composers, like Varèse, Schillinger, Martinů and Percy Grainger wrote for it, creating a repertoire; and, as we have seen, because the Theremin responded much like a traditional instrument to a performer's micro-gestures, it could articulate as a direct extension of the human body. When, in 1930, the Radio Corporation of America licensed it for manufacture, it also became the first electronic instrument to be mass-produced. In all, some 200 Therminvoxes were bought by radio stations, composers and members of the public but, as the great depression deepened and Termen himself mysteriously vanished into the aether, its star began to wane.

Yet, by the late 1940s, the Theremin had found a new niche for itself in film, where it became a musical signifier for the uncanny, the disorientated, the alien and the extraterrestrial. One of the first Hollywood composers to establish this was the Hungarian expatriate, Miklós Rózsa in his classic score for *Lost Weekend* – Billy Wilder's 1945 hymn to alcoholic hallucinosis. Since we heard that in PROBES #3, here's an excerpt instead from another of Rózsa scores, this one Alfred Hitchcock's *Spellbound*, which was released in the same year.

[Miklós Rózsa, 'Spellbound Concerto' (excerpt), 1945]

[Theremin Cello]

By this time, theremins were quite thin on the ground and the only registered player in Los Angeles was a Dr. Samuel Hoffman. He'd acquired his in settlement of a debt in 1929 and began in his leisure time to feature it, first in the nine-piece swing orchestra he'd founded in 1936 and then again in Hal Hope's Electronic Trio – which consisted of a Theremin, a Theremin cello and a Hammond organ. Tragically, once again, there are no recordings. By the time he'd moved to Los Angeles in 1941 to work full time as a dentist, he'd given up playing professionally but Hollywood found him and he quickly became the film composers' go-to Theremin player for everything; it was a job that kept him busy for the next twenty years. Death didn't catch up with him until 1967 – and not before he'd played on our theme song for these electronic chapters:

[Captain Beefheart and His Magic Band, 'Electricity' (excerpts), 1967]

Yes, that was Dr. Hoffman, and here he is again in 1951, playing on Bernard Herrmann's definitive sci-fi soundtrack for the Robert Wise classic *The Day the Earth Stood Still,* scored for two Theremins, two pianos, a harp, a tuba, an electric violin, a Wurlitzer organ and miscellaneous percussion.

[Bernard Herrmann, 'The Day the Earth Stood Still - Prelude', 1951]

And there are still new uses for the theremin today; here's an excerpt from the Spanish thereminist Javier Díez-Ena's 'Berlin Ghost Opera' – on which everything is played by Theremins.

[Javier Díez-Ena, 'Berlin Ghost Opera' (excerpt), 2017]

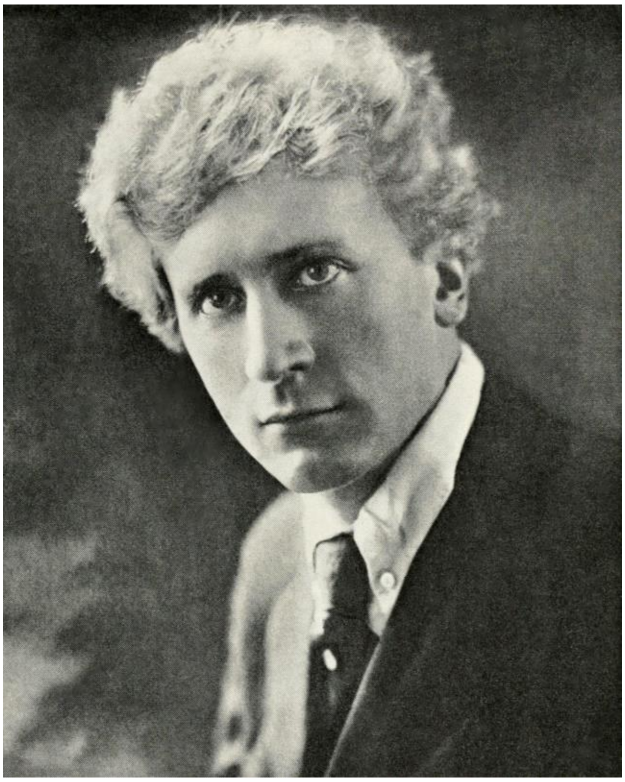
And here's the Austrian trio BlueBlut, sounding here a little like Magma, featuring thereminist Pamelia Stickeney.

[BlueBlut, 'Bondage' (excerpt), 2014]

Termen's other instruments fared less well. The Terpsitone used the movements of a dancer to control the sound, working from a metal plate installed beneath a dance platform that acted as a pitch antenna. This was a great idea, but it seems to have been too hard to control and Termen never found a dancer who could take it further.[11] Then, in 1926, he premiered the Keyboard Electric Harmonium, a polyphonic, three-octave keyboard with variable tuning that could accommodate 1,200 micro-tonal divisions to the octave and had twelve dials with which to mix multiple timbres. There are no recordings of this and nobody wrote for it, but Andrey Smirnov still has a working model in Moscow. A revised version of the Fingerboard Theremin – or Theremin Cello – came next in 1929, an instrument first unveiled in Leningrad, in 1922. The revision was a commission from bad-boy conductor Leopold Stokowski, who wanted to beef up the cello section of his Philadelphia Orchestra. It looked like a cubist cello, and the player's left hand fingered a black plastic ribbon that ran the length of the neck, while the right hand controlled the volume with a lever set into the body. There was even a contrabass version, specially built for Stokowski – but it was quickly abandoned when its ultra-low frequencies made the cello section nauseous. Edgard Varèse commissioned two higher pitched versions for his 1934 composition, 'Equatorial', which were featured in the premiere but replaced in the final score with the more flexible Ondes Martenot. And somewhere between 1930 and 1932, there was the Keyboard Theremin[12] which was specifically designed to emulate the timbres of other instruments and, like the Ondes Martenot, was fitted with a fixed-pitch keyboard as well as a cello-style continuous controller ribbon, allowing players to use either mode of articulation. We have no idea what this sounded like, but it was integral to the legendary 1932 Carnegie Hall concert that featured the ten-piece Theremin Electrical Symphony Orchestra. The Keyboard Theremin was also the centrepiece of the Electrio – which also featured an Electric Harmonium and a Theremin Cello and broadcast light music every week on CBS Radio in New York. Again, neither the orchestra nor the trio was ever recorded.

But the Theremin Cello was. Here's a recent recording of Marieke van der Heiden playing Stokowski's arrangement of the early 18th century German composer Johann Mattheson's 'Aria', from his 'Suite No. 5 in C minor'.[13]

[Johann Mattheson, 'Aria from Suite No. 5 in C minor', 1714 or before]



[Percy Grainger]

An electronic orchestra, an all-electronic trio – what did they play, these alien instruments of the future – something mind-altering, experimental, futuristic? They played selections from the popular classics in a textbook example of what Marshall McLuhan called rearview mirrorism – in which a new technology simply imitates the one it was intended to replace.[14]

Only Edgard Varèse and Percy Grainger actively explored new musical ideas with the Theremin; in particular Grainger, who accepted portamenti as something to be embraced rather than overcome, and who was one of the only composers of the time to connect the affordances of the new technology with the exploration of new musical forms. Here's his 'Free Music No. 1', for four Theremins, completed in 1936 and performed here by Lydia Kavina.

[Percy Grainger, 'Free Music No.1', 1936]

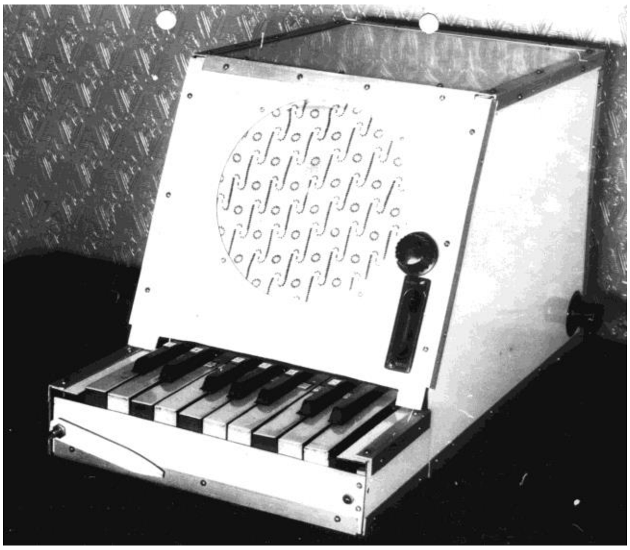
Only with the Polyrhythmophone, now better known as the Rhythmicon, did Termen work directly toward an unconventional, not to say experimental, musical programme. When we come to the rhythm PROBE chapters of this series, we'll look at that more closely, because it has important implications – but for now it's enough to say that both the idea and the commission for the machine – as well as the identification of the problem to be solved – came from the American experimentalist Henry Cowell, who wanted to test a theory he'd propounded in his 1930 publication, *New Musical Resources*,[15] in which he argued that useful structural parallels existed between pitch-ratios and pulse-ratios that could be exploited for compositional purposes. The trouble was that the rhythmic relationships he was proposing were beyond the ability of human players to realise, so he hoped that an electro-mechanical device would be able not only to generate the precise number of beats per second he needed – but also to play a lot of them at the same time – all at different ratios to a basic pulse. To achieve this – at Cowell's suggestion – Termen used perforated spinning discs to interrupt the flow of light between bulbs and photoreceptors, establishing oscillations which – depending on the speed of the discs – would be heard as rhythms or pitches. Termen's machine was able to sound sixteen different pulses simultaneously – all of whose ratios mirrored those of the natural overtone series.[16] It worked, but not with sufficient nuance to do more than demonstrate a principle. Cowell composed several pieces for it, one of which – 'Rhythmicana' – was possibly played once – different sources don't agree. We do know, however, that there was a public demonstration in 1932, which elicited considerable media interest but still no recordings were made. Cowell himself quickly moved on: the idea was strong, but the reality had proved too limited to produce work of any heft.[17] 'Rhythmicana' was finally revived – or premiered – in 2019, at Tufts University, by the Tufts Musical Ensemble. The Rhythmicon they used was reconstructed for the purpose by Mike Buffington at the request of one Wouter Andre 'Wally' de Backer, composer and singer of the Australian Indie band The Basics.[18] And if a pop person reviving an antique electronic instrument seems a little unusual, as we'll see in future episodes, it's actually almost the rule. Here's a short excerpt from that Boston concert of Cowell's 1931 'Rhythmicana', scored for Rhythmicon and orchestra.

[Henry Cowell, 'Rhythmicana' (excerpts), 1931]

In 1938, after eleven high-profile years in New York, Termen suddenly vanished, leaving a wife, a reputation and a business behind. It would be 30 years before anyone outside Russia would even know if he were still alive. But for that story I refer you to Albert Glinsky's excellent 'Ether Music and Espionage'.[19] Termen's disappearance ended his work on new instruments. But by then many others were ploughing similar ground.

In the next episode we'll follow the heterodyne trail through a range of other experimental monophonic instruments and their exploration of increasingly sophisticated signal processing.

1 I use the word 'ecology' analogically, to invoke a mechanism: the symbiotic interdependence of an organism with it's environment and the way that this impacts on the evolution of organisms and systems to create 'ecospheres'.
2 We learn to music in the same way that we learn to speak, by internalizing rules of inclusion, exclusion and combination.
3 Marshall McLuhan, Understanding Media: The Extensions of Man. McGraw Hill, 1964.



[Rhythmicon]

4 The Denis D'or, the 'Golden Dionysis', was an early one-off keyboard instrument built by the Czech theologian and pioneer of electrical research Václav Prokop Diviš (1698 – 1765).
5 Invented as a hand-held device by Greg Heet in 1969 and introduced in 1976. When held over metal strings it perpetuates their vibration to produce continuous tones.
6 In all there were in all three built: the prototype, a second and then a third, in 1911.
7 That's why frequencies are defined in cycles per second, or Hertz.
8 It was the template for all the tonewheel organs of the future – and of additive synthesis. It inspired Ferruccio Busoni to write his Sketch of a New Aesthetic of Music, in 1907 – which in turn inspired Luigi Russolo, Edgard Varèse, John Cage and a generation of composers dreaming of new sounds and electronic music.
9 See Probes #18
10 Cahill built the Telharmonium with the ability to create microtonal divisions and scales – it really was a like a human brain, inasmuch as only the tiniest portion of what it was capable of was ever utilized. In its short life, this phenomenal machine only pumped out light classics and popular potboilers. The community of microtonal composers who were active at the time – and who could have negotiated with Cahill to work with his universal pitch machine in downtime, or in the middle of the night – seem to have missed its possibilities altogether.
11 At the 1932 Carnegie Hall concert, it was demonstrated by the theremin virtuoso Clara Rockmore (then Reisenberg) who was impressed with its possibilities. But those possibilities were never followed up.
12 The instrument had two foot-pedals to shape the sound and to add vibrato, and a series of organ-like stops to emulate the timbres of conventional instruments, such as the organ, piano, brass and woodwind – as well as percussive timpani effects. The amplified output of 100 Watts was fed into a bank of six twelve-inch speakers.
13 University of Illinois Press, 2000.
14 Thijn Vermeulen at the piano
15 And, to be fair, Termen was a classical cellist, not an avant-gardist.
16 Published in 1930 and still in print.
17 See Probes #2.
18 Of the three instruments built, two are still in working order.
19 In the early 1990s, the Russian composer Сергей Плаксин had also recreated a Rhythmicon, or something very similar, based on Theremin's original work. Thanks to Thom Holmes for this information.

02. Notes

On length and edits.
The purpose of these programmes is to give some practical impression of the probes we discuss. This necessitates for the most part extracting short stretches of music from longer wholes, which, of course, compromises the integrity and disrupts the context inherent in the original works. I have also, on occasion, edited different sections of a longer work together, better to illustrate the pointsunder discussion. So the examples played in the programmes should not be confused with the works themselves. Wherever the word (excerpt) appears after a title in the programme transcript, this indicates that what follows is an illustration, not a composition as it was conceived or intended. If something catches your ear, please do go back to the source.

Notification
If you want to be notified when a new probe goes up, please mail rermegacorp@dial.pipex.com with subject: Probe Me.

03. Acknowledgments

With special thanks to Bob Drake, Jonas Vognesen, Philppe Glandien, Simon Emmerson,Yasushi Utsunomiya, Yumi Hara, Tim Hodgkinson, Leslie Dalaba, Silvia Tarrozi, John Edwards, Anna Ramos, Carolina Eyck, Nick Didkovsky and Peter Blegvad (the new voice of footnote).

And special thanks to Thom Holmes* for his oversight, suggestions, script-reading and fact-checking.

*Author *of Electronic and Experimental Music*, Routledge 2008 (3rd Edition) and curator of Noise and Annotations: https://www.thomholmes.com

04. Copyright note


[Clara Rockmore]