PART I

Electronic music in context

1 The origins of electronic music

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Classical visions

> We have also sound-houses, where we practise and demonstrate all sounds and their generation. We have harmony which you have not, of quarter-sounds and lesser slides of sounds. Divers instruments of music likewise to you unknown, some sweeter than any you have; with bells and rings that are dainty and sweet. We represent small sounds as great and deep, likewise great sounds extenuate and sharp; we make divers tremblings and warblings of sounds, which in their original are entire. We represent and imitate all articulate sounds and letters, and the voices and notes of beasts and birds. We have certain helps which, set to the ear, do further the hearing greatly; we have also divers strange and artificial echoes, reflecting the voice many times, and, as it were, tossing it; and some that give back the voice louder than it came, some shriller and some deeper; yea, some rendering the voice, differing in the letters or articulate sound from that they receive. We have all means to convey sounds in trunks and pipes, in strange lines and distances. Francis Bacon, *The New Atlantis* (1626)[1]

The origins of electronic music lie in the creative imagination. The technologies that are used to make electronic music are a realisation of the human urge to originate, record and manipulate sound. Although the term *electronic music* refers specifically to music made using electronic devices and, by extension, to certain mechanical devices powered by electricity, the musical possibilities that these technologies have opened up are a recurring theme in literature, art, engineering and philosophy. But it was not until the turn of the twentieth century, when electronic and electromechanical instruments started to become a physical reality, that certain forward-looking musicians began to turn to the new possibilities already imagined by others.

Francis Bacon's celebrated description of a modern sound studio is one of many examples of such a creative imagination. *The New Atlantis*, written in 1624 and published in 1626, was a utopian tale of mariners in the south-eastern seas who were shipwrecked upon an island containing a model civilisation, in which science and spirituality found union. The 'sound-houses' passage is one of a series of descriptions, given by the island's governor, of its various knowledge resources and houses of learning.

Bacon was familiar with some of the most experimental technologies of his time, including those devised by Salomon de Caus (1576–1626), a Frenchman who moved to England in 1612, to work as a garden designer and engineer specialising in hydraulics. De Caus created steam engines, fountains and many water-driven musical instruments including a player-piano, mechanical songbirds and various organs.

Bacon himself wrote an essay 'On Gardens', but the description of imaginary technologies of music in the 'sound-houses' text goes much further than merely reproducing the contemporary mechanical devices used in garden displays. It seems to express a desire to expand musical language beyond the familiar pitch-based system of Western instrumental music, to incorporate sound processing, novel timbres, microtonal tunings, amplification, recording, spatialisation – in short, every technique known to electronic music.

Bacon's frame of reference was as much classical as contemporary. The majority of his work and thought arose from a rejection of the received wisdom of the period, founded upon Plato and Aristotle, and an enthusiastic reappraisal of the pre-Socratic philosophers, such as Epicurus (341–270 BC), Democritus (460–370 BC) and Thales (*c.* 635–543 BC). These philosophers developed a theory of matter. Thales argued for an underlying unity based on the idea that the world was made from water. Democritus developed this idea to suggest that all matter is made from imperishable indivisible elements called atoms, which are surrounded by a void, and have various characteristics (size, shape, mass, etc) whose complex interactions give rise to physical reality. Epicurus in turn refined Democritus by theorising that the atoms are in continuous state of parallel motion from an absolute high to an absolute low. Every so often, one atom inexplicably makes a slight swerve (the *clinamen*) in its path, creating a chain reaction of collisions, which give rise to matter. The theories of these 'atomist' philosophers seem largely to have come from their imaginations, but there was at least *some* experimental basis for their ideas. Thales, for example, wrote that amber rubbed with animal fur could lift straw and feathers, and Democritus observed fire to conclude that motion is inherent to atomic particles.

Bacon was not the only sixteenth/seventeenth-century scientist interested in these ideas. In 1600, William Gilbert published *De Magnete, Magneticisque Corporibus, et de Magno Magnete Tellure* (On the Magnet and Magnetic Bodies, and on That Great Magnet the Earth) which contains the first discussion of an 'electric force'. This was static electricity, and Gilbert made explicit reference to the pre-Socratic philosophers' discovery of the attractiveness of rubbed amber. The word 'elektron' is Greek for 'amber', and the Latin word 'electricus' means 'produced from amber by friction'.

Some of the elements required for 'electronic' music already existed at this time.

Music theory in the sixteenth century was in the grip of a debate about tuning systems. Writers such as Nicola Vicentino (1511–*c.* 1576) were defending just intonation against the steady rise of compromised tuning systems such as meantone and equal temperament. The adoption of these latter systems enabled both musical instruments and, ultimately, published music notation, to be disseminated across Europe. The central importance given to pitch and hence harmony in music theory led to a musical practice which ignored most of the sound-based concepts described in Bacon's text.

Vicentino's *L'antica musica ridotta alla moderna prattica* (ancient music adapted to modern practice), published in Rome in 1555, outlined his interpretation of the music theories of Pythagoras (569–475 BC), Aristoxenus (fourth century BC), Ptolemy (*c.* 90–168 AD) and Boethius (*c.* 480–525 AD). Vicentino himself built a number of instruments, such as the *archicembalo*, a keyboard with thirty-six keys to the octave, designed to play the Greek *genera* (diatonic, chromatic, enharmonic) derived from Pythagoras's discovery of a *harmonic series* made up of whole-number ratios subdividing a vibrating string or other body.

Other theorists, however, were less interested in the refinements of such 'just' intonations than in the development of a musical language that was reproducible and standardised, with an accompanying notation system that similarly privileged pitch. The meantone tuning system[2] deliberately detuned certain intervals (particularly fifths) in order to achieve the maximum number of 'pure' thirds. Equal temperament systematically detuned all the fifths in order to achieve a 'cycle' that is both effective and practical. This solution is still the dominant western musical tuning system today.

The source of all these theories of tuning, Pythagoras, was also the leader of an elitist cult, which was divided into an inner circle called the *mathematikoi* and an outer circle called the *akousmatikoi*, or 'listeners'.[3] The latter were obliged to listen to the master from behind a curtain, a practice which has given its name to present-day *acousmatic* music in which the original source of the sound is not visually apparent, the immediate source being the loudspeakers which are apparent. Where acousmatic music explores a 'sound-houses' model, by manipulating and processing sound, the instrumental tradition, on the other hand, uses a pitch-centred model, and ultimately abandons Pythagoras in favour of the pragmatic distortion of nature that is equal temperament. It is only as electronic technologies have become available that the music envisaged by Bacon (and perhaps Pythagoras too) has become a reality. However, the absence of these technologies in the intervening years did not eliminate the urge to create this kind of music.[4]

Automata

The eighteenth century saw a surge of interest in mechanical musical devices such as carillons, music-boxes and mechanical organs of various types. The most celebrated engineer was Jacques Vaucanson (1709–82), whose machines took on a life of their own by mimicking natural and biological functions. His life-size flute-player (1738) blew, breathed and played twelve different melodies so convincingly like a human being that it surpassed previous mechanical devices. This *automaton*, or self-operating machine, started to resemble a robot in its simulation of human action. Vaucanson's most celebrated automaton was a duck, which moved its wings, legs and body, quacked and, most amazingly, both ate food and dabbled in the water. Vaucanson was keen to reveal the inner workings of the duck, showing the 'digestive' tubing through which the food passed, the throat, and so on.

Vaucanson had numerous imitators, and the general spirit of mechanical and scientific experiment at that time was contagious. New musical instruments were also created with varying amounts of automation, and there was even an electronic instrument: the *claveçin électrique*, built in Paris in 1761 by Jean-Baptiste Delaborde, which used statically charged clappers to ring bells, controlled by a harpsichord keyboard. The fascination with automata was also pursued in contemporary philosophy, most notably in the writings of Julien de La Mettrie (1709–51). In *L'homme machine* (Man a Machine) (1748), La Mettrie developed his ultra-materialist, atheistic vision of man as a machine made from a single universal substance. In doing so, he set himself against the prevailing Cartesian idea that mind and body are separate and occasioned the wrath of many of his contemporaries. Not that this bothered him: he cheerfully asserted the idea that we only have one life and it is our duty to enjoy ourselves as much as possible while we are alive. He duly lived fast and died young.

As the interest in automata grew, so did the concept of an artificial intelligence (although that phrase was not itself used at the time). The most celebrated example of this was a hoax, but the fact that people were fooled gave rise to a large amount of imaginative fiction that predicted, amongst other things, electronic music. Once again, the creative imagination (in this case the literary imagination) anticipated developments which musicians themselves ignored.

The hoax in question was a turban-wearing chess-playing automaton popularly known as 'The Turk'. It was created in 1769 by Baron Wolfgang von Kempelen, and its most famous exploit was to beat Napoleon Bonaparte at chess. Von Kempelen passed on 'The Turk' to Johann Maelzel (1772–1838), who was developing a reputation as an inventor and showman. Among

Maelzel's inventions was the Maelzel Metronome (after which the 'MM' marking at the beginning of musical scores is named) which was adopted by Ludwig van Beethoven. Maelzel also created a musical machine called a 'panharmonicon', for which Beethoven wrote his piece *Wellington's Victory*.[5] Maelzel toured 'The Turk' widely and created a sensation wherever he went. In the 1830s it visited America, where Edgar Allan Poe finally exposed the truth in an essay entitled 'Maelzel's Chess-Player', published in the *Southern Literary Journal* in 1836. The truth was that 'The Turk' concealed a human chess-player, a deception which finds echoes today. When the world chess champion, Garry Kasparov, was first beaten by the IBM computer 'Deep Blue' in 1997, he had no hesitation in calling foul, claiming that one crucial move had in fact been made by a human being. The rest of the match (which Kasparov lost) was played in an atmosphere of rancour, secrecy, accusation and counter-accusation, and 'Deep Blue' was immediately mothballed at the end.

The literary imagination

The first major writer to be inspired by such automata to apply their capabilities to music was E. T. A. Hoffmann (1776–1822). In his story 'Automata' (1814), after a lengthy description of 'The Turk', and a concert by musical automata, the main characters fall to debating the musical possibilities of as yet only imaginary technologies.

> Now, in the case of instruments of the keyboard class a great deal might be done. There is a wide field open in that direction to clever mechanical people, much as has been accomplished already; particularly in instruments of the pianoforte genus. But it would be the task of a really advanced system of the 'mechanics of music' to observe closely, study minutely, and discover carefully that class of sounds which belong, most purely and strictly, to Nature herself, to obtain a knowledge of the tones which dwell in substances of every description, and then to take this mysterious music and enclose it in some sort of instrument, where it should be subject to man's will, and give itself forth at his touch. All the attempts to evoke music from metal or glass cylinders, glass threads, slips of glass, or pieces of marble; or to cause strings to vibrate or sound in ways unlike the ordinary ways, are to me interesting in the highest degree . . . according to my theory, musical sound would be the nearer to perfection the more closely it approximated such of the mysterious tones of nature as are not wholly dissociated from this earth.

In 1831, Honoré de Balzac (1799–1850) wrote a story called 'Gambara', about an eccentric composer who devises a fantastic instrument called the 'panharmonicon' (clearly inspired by Maelzel), which sets out to explore the relationship between all sounds, thoughts and emotions. As he says:

> Composers work with substances of which they know nothing. Why should a brass and a wooden instrument – a bassoon and horn – have so little identity of tone, when they act on the same matter, the constituent gases of the air? Their differences proceed from some displacement of those constituents, from the way they act on the elements which are their affinity and which they return, modified by some occult and unknown process. If we knew what the process was, science and art would both be gainers. Whatever extends science enhances art.

The result of Gambara's efforts is that he is dismissed as a madman. The music he creates is judged to be too far ahead of its time, too incomprehensible, by his audience.

At almost the same time as Balzac's story was published, Ada Byron, Lady Lovelace (1815–52) met Charles Babbage at Cambridge. Babbage had partially built a calculating machine, or 'Difference Engine', and was planning a more sophisticated 'Analytical Engine'. This was an early model for a programmable computer, and Ada Byron immediately recognised the potential for the 'universality' of the device. Writing in 'The Sketch of the Analytical Engine' of 1843, she describes all aspects of Babbage's machine, including this passage about its musical application:

> Again, it might act upon other things besides number, were objects found whose mutual fundamental relations could be expressed by those of the abstract science of operations, and which should be also susceptible of adaptations to the action of the operating notation and mechanism of the engine . . . Supposing for instance, that the fundamental relations of pitched sounds in the science of harmony and of musical composition were susceptible of such expression and adaptations, the engine might compose elaborate and scientific pieces of music of any degree of complexity or extent.

Ada Byron passionately advocated Babbage's concept, although a working machine was never completed, thanks partly to her early death. She may nevertheless be regarded as the first computer programmer. Her writings, although scientifically and technically grounded, display the same tendency to Romantic vision as those of her own father, the poet Lord Byron.

The combination of science with fiction is a theme in the work of E. T. A. Hoffmann, Balzac and Mary Shelley, who created perhaps the most sophisticated fantasy of an artificial life in *Frankenstein* (1816). The monster, it will be recalled, is awakened by electricity by using a lightning-rod. This was undoubtedly inspired by the discoveries of Benjamin Franklin, himself a musical inventor,[6] who first flew a kite designed to conduct electricity in 1750. As the nineteenth century developed, so such fantastic stories proliferated, mixing scientific discoveries with pure imagination to create forerunners of what would eventually be called 'science fiction'.

Some mystical and visionary writings of the nineteenth century also contain descriptions of musical possibilities enabled by new technologies that prefigure electronic music. A typical example occurs in the novel *A Crystal Age* (1887) by W. H. Hudson (1841–1922), in which seven highly polished brass globes hover in the air, driven by an unknown power and emitting sound until the air is 'palpitating with strange exquisite harmony'. Even more extraordinary is the following extract from Edward Bellamy's (1850–98) novel *Looking Backward* (1888). The hero, Julian West, awakens in Boston in the year 2000, after more than a century of sleep, to find the world changed beyond recognition and with most of the social problems of his time resolved. In describing the world of the future he outlines numerous imaginary technologies, including the following description of a music system. It is Julian West's hostess, Edith, who is speaking:

> 'There is nothing in the least mysterious about the music, as you seem to imagine. It is not made by faeries or genii, but by good, honest, and exceedingly clever human hands. We have simply carried the idea of labor-saving by cooperation into our musical service as into everything else. There are a number of music rooms in the city, perfectly adapted acoustically to the different sorts of music. These halls are connected by telephone with all the houses of the city whose people may care to pay the small fee, and there are none, you may be sure, who do not. The corps of musicians attached to each hall is so large that, although no individual performer, or group of performers, has more than a brief part, each day's program lasts through the twenty-four hours. There are on that card for today, as you will see if you observe closely, distinct programs of four of these concerts, each of a different order of music from the others, being now simultaneously performed, and any one of the four pieces now going on that you prefer, you can hear by merely pressing the button which will connect your house wire with the hall where it is being rendered. The programs are so coordinated that the pieces at any one time simultaneously proceeding in the different halls usually offer a choice, not only between instrumental and vocal, and between different sorts of instruments, but also between different motives from grave to gay, so that all tastes and moods can be suited.'

This not only seems to realise Bacon's description of 'sounds in trunks and pipes', but is also a highly prophetic description of a radio broadcast network, or even of download culture.[7] However, there are also some parallels between Bellamy's imaginary technologies and contemporary inventions. In 1876, Elisha Gray had created a 'Musical Telegraph' which transmitted single note oscillations along wires. In 1898, Valdemar Poulson patented a magnetic 'Telegraphone', which could both record and play back sound and, in 1897, Thaddeus Cahill patented the *Art of and Apparatus for Generating and Distributing Music Electronically*. This idea of a telegraph-based music distribution system led to the construction of the first really influential electronic musical instrument. Cahill's *Dynamophone* or *Telharmonium* appeared in 1906, weighing about two hundred tons and measuring about eighteen metres in length.[8] It used 145 modified dynamos with geared shafts and associated inductors to produce alternating currents of different audio frequencies.

Sound recording

In his classic essay 'The Work of Art in the Age of Mechanical Reproduction' (1936), Walter Benjamin makes the following argument about the effect on art of the technologies of reproduction, including sound recording: 'for the first time in world history, mechanical reproduction emancipates the work of art from its parasitical dependence on ritual. To an ever greater degree the work of art reproduced becomes the work of art designed for reproducibility.' The 'ritual' to which he refers is the performance, a unique set of circumstances under which an individual or a group experiences a work of art.

The beginnings of this fundamental change in the way music is experienced and consumed lie in the later part of the nineteenth century, although some purely mechanical recording devices, such as the musical box and the player-piano, existed earlier. One such device worth noting was the *phonautograph*, invented in 1857 by Leon Scott. This recorded a sound through a vibrating membrane attached to a pen which drew a line resembling the waveform. This could only record, however, and could not reproduce the original sound.

The earliest microphones were, strictly speaking, the telephone transmitter devices invented by Elisha Gray and Alexander Graham Bell, but Emile Berliner is usually credited with the invention of the first true microphone in 1877. However, when Thomas Edison invented the carbon microphone later in the same year, his was the first to become commercially available. Edison also invented the phonograph in 1877, although a Frenchman, Charles Cros, came up with the same idea independently and slightly earlier. The phonograph used a similar principle to the phonautograph, except that the pen drew grooves into a relatively soft material (wax, tin foil or lead). These grooves could then be retraced by a needle and amplified mechanically. It was not long before this system was mass produced. In 1887, Emile Berliner patented a phonographic system using flat discs rather than cylinders, called the gramophone.

Loudspeakers were invented independently by Ernst Werner von Siemens in 1877, and Sir Oliver Lodge, who patented the design of the modern moving-coil loudspeaker in 1898. These, combined with both the electromechanical and magnetic systems described above, evolved rapidly. By the early 1930s, electrical recordings would become a viable medium thanks to the invention of magnetic tape recording in 1928 by Fritz Fleumer in Germany.

The impact of recorded and reproducible sound on music in general was, of course, enormous. However, it was some time before composers and musicians began to realise the creative potential of this new medium. With a few exceptions, such as Ottorino Respighi's inclusion of a phonograph (playing birdsong) in his orchestral composition *Pini di Roma* (Pines of Rome) in 1924, these technologies were used purely for the reproduction of live sounds or musical performances. The systematic exploration of tape music had to wait until the early 1950s, when Pierre Schaeffer began his experiments.

Early 'electronic' music

'Electronic' music therefore began with the invention of new electronic instruments, even though they were normally seen as novelties or curiosities. A good example, and probably the first truly electronic instrument, was the *Singing Arc*, invented by William Duddell in 1899, which used the sounds emitted by carbon arc lamps (the precursors of the electric light bulb). It was some time before electronic instruments would come to be included alongside their acoustic counterparts but, even so, Western music was already beginning to evolve to a point at which such new means of expression would be required. Composers were exploring musical material in a variety of different ways, and some of these started to focus upon the sonic and timbral properties that the pitch-centred notation system had marginalised.

One such example was the third of the *Fünf Orchesterstücke* (Five Orchestral Pieces) Op. 16, composed in 1909 by Arnold Schoenberg. This movement, entitled 'Farben' (Colours), had neither melodic contour nor harmonic direction, but rather featured a fairly static sound-mass built from a single chord which changed timbre, or colouration. The skill of the orchestration emphasised the acoustic and tonal properties of the instrumental combinations and the work is quite startling in its anticipation of 'spectral' music. However, this was not a direction that Schoenberg pursued in his subsequent work, preferring to continue to overturn the orthodoxies of the tonal system instead.

The first leading composer who seems to have realised the potential for an entirely new musical language that could also use the new technologies was Ferruccio Busoni, who wrote in his *Sketch for a New Aesthetic of Music* (1907):

> We have divided the octave into twelve equidistant degrees because we had to manage somehow, and have constructed our instruments in such a way that we can never get in above or below or between them. Keyboard instruments, in particular, have so thoroughly schooled our ears that we are no longer capable of hearing anything else – incapable of hearing except through this impure medium. Yet Nature created an infinite gradation – *infinite!* Who still knows it nowadays? . . . While busied with this essay I received from America direct and authentic intelligence which solves the problem in a simple manner. I refer to an invention by Dr. Thaddeus Cahill. He has constructed an apparatus that 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.

Although Busoni's own compositions did not themselves explore these new avenues, his visionary ideas and his teaching inspired others to do so. In 1908, Gabrielle Buffet, having graduated from the Schola Cantorum, went to Germany to join her fellow student Edgard Varèse. Both of them were so fascinated with the *Sketch for a New Aesthetic of Music* that they actually tried to build machines to realise Busoni's ideas. Buffet noted in her essay *Music of Today*: 'With the help of and through improvements to these sound-machines, an objective reconstitution of the life of sound could be possible. We would be discovering sound-forms independently of musical conventions.'[9]

Sound in art

At the same time that Buffet and her contemporaries were becoming excited by the new musical possibilities being opened up by technological innovations, a number of leading painters were developing an abstract art that drew heavily on music. The 'Blue Rider' group, Der Blaue Reiter, included Arnold Schoenberg and Wassily Kandinsky (1866–1944), who began to paint 'Improvisations' and 'Compositions' during the years immediately preceding the First World War. Kandinsky was inspired by Theosophy and other spiritual ideas to create work that aspired to the condition of music. He also experienced synaesthesia, in which the senses become confused, by 'hearing' specific sounds when seeing certain colours or shapes (yellow as the note C played on a trumpet, for example). Many other artists and composers explored these ideas: for example, Alexander Skryabin (1872–1915) whose *Prometheus: The Poem of Fire* (1910) included a part for 'light organ', which was intended to bathe the concert hall in colour from electric lights corresponding to the changing tonality of the music.

In June 1912, Buffet and her husband, Francis Picabia, accompanied the artist Marcel Duchamp and the poet Guillaume Apollinaire to a performance of *Impressions d'Afrique* (Impressions of Africa) at the Théâtre Antoine, Paris. This was a staged version of a novel by Raymond Roussel, in which various bizarre machines and musical instruments were powered by (amongst other things): a thermo-sensitive chemical called Bexium; drops of heavy water let fall by a large worm; extended vocal techniques; resonating pulmonary braid; and lightning. All four artists, in their different ways, were inspired by this performance, and went on to become leading figures in Dada, the absurdist movement which arose in 1916/17 (initially in Zurich) out of disgust at the First World War. According to Hugo Ball, the Dada cabaret included African music, a balalaika orchestra, and Dada music by composers such as Erwin Schulhoff. However, for electronic music, a far more significant innovation was 'sound poetry'.[10]

The experimental use of the human voice to use phonetic (rather than semantic) sounds as poetry was probably pioneered by Hugo Ball sometime before 1915: 'I created a new species of verse, "verse without words," or sound poems . . . I recited the following: gadji beri bimba glandridi lauli lonni cadori . . .'[11]

However, there was a close correspondence between Dada and the Italian Futurists, led by F. T. Marinetti, who in 1914 published *Zang Tumb Tumb*, a sound-poetic attempt to convey the noises of battle[12] using typography and 'free words'.

It was this daring and iconoclastic text that inspired Luigi Russolo to write his manifesto *L'arte dei rumori* (The Art of Noises) in 1913, and to build *intonarumori* ('intoners' or 'noise machines') with which to perform Futurist music. *The Art of Noises* is an important text in the history of electronic music, because it is the first attempt seriously to categorise all sounds and, indeed, to treat them as potential music. In a crucial passage, Russolo wrote:

> Every manifestation of our life is accompanied by noise. The noise, therefore, is familiar to our ear, and has the power to conjure up life itself. Sound, alien to our life, always musical and a thing unto itself, an occasional but unnecessary element, has become to our ears what an overfamiliar face is to our eyes. Noise, however, reaching us in a confused and irregular way from the irregular confusion of our life, never entirely reveals itself to us, and keeps innumerable surprises in reserve. We are therefore certain that by

selecting, coordinating and dominating all noises we will enrich men with a new and unexpected sensual pleasure.

Although it is characteristic of noise to recall us brutally to real life, the art of noise must not limit itself to imitative reproduction. It will achieve its most emotive power in the acoustic enjoyment, in its own right, that the artist's inspiration will extract from combined noises.

Here are the 6 families of noises of the Futurist orchestra which we will soon set in motion mechanically:

1.	2.	3.	4.	5.	6.
Rumbles:	Whistles:	Whispers:	Screeches:	Noises obtained by percussion:	Voices of animals and men:
Roars	Hisses	Murmurs	Creaks	Metal	Shouts
Explosions	Snorts	Mumbles	Rustles	Wood	Screams
Crashes		Grumbles	Buzzes	Skin	Groans
Splashes		Gurgles	Crackles	Stone	Shrieks
Booms			Scrapes	Terracotta	Howls
				Etc.	Laughs
					Wheezes
					Sobs

In this inventory we have encapsulated the most characteristic of the fundamental noises; the others are merely the associations and combinations of these.

The *intonarumori* included percussion, but also a range of machine-like instruments deriving from the categories above. Russolo even devised a graphic notation for scoring his noise music, and achieved notoriety in 1914 after performances in Milan and London. After the war the *intonarumori* were recorded in combination with classical orchestras, but none of the original instruments survives today.

The spirit of Dada and Futurism permeated through to mainstream concert music. In 1917, Erik Satie included the 'Futurist' sounds of sirens, starting pistols, typewriter and a foghorn in his ballet *Parade* (although he did so only at the request of the poet Jean Cocteau), and in 1924 Georges Antheil created his *Ballet mécanique*, which included electric bells, airplane propellers and a siren in its orchestra of multiple percussion, pianos and player-pianos. Electronic instruments such as the *Theremin*, invented by Professor Lev Termen (Leon Theremin) *c.* 1919–20; the *Trautonium*, invented by Friedrich Trautwein *c.* 1929; and the *Ondes Martenot*, invented in 1928 by Maurice Martenot, also began to appear regularly in concerts around this time.

Electronic music

The inclusion of electronic sounds in conventional music does not in itself amount to the origins of an electronic *music*, as distinct from any other kind

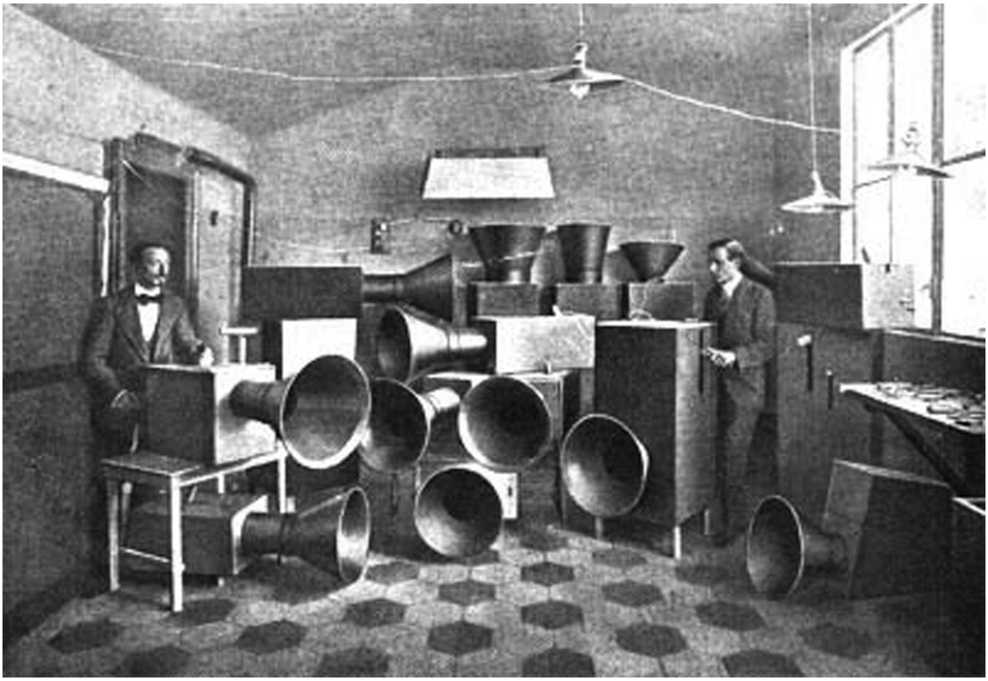

Figure 1.1 Russolo's *intonarumori*

of music. Electronic music is a synthesis of many different aspects of what has already been described: the array of loudspeakers, or acousmatic situation; the creation of new electronic instruments; the exploration of novel tunings and timbres; the use of recording and reproduction technologies; the relationship between science, mathematics and music. Certain compositional techniques which are features of electronic music have their roots in much earlier music. To take one example, algorithmic composition, which uses a strict set of rules to compose music, can be traced back through voice-leading counterpoint to the metrical procedures of certain types of late medieval music. Electronic music has, thanks largely to digital technologies, been able to make algorithms that are more complex and more diverse, by including chance and extreme determinism, artificial intelligence and generative processes.

In 1937, the composer John Cage delivered a highly prophetic lecture in Seattle, entitled 'The Future of Music – Credo':

> I BELIEVE THAT THE USE OF NOISE
> Wherever we are, what we hear is mostly noise. When we ignore it, it disturbs us. When we listen to it, we find it fascinating. The sound of a truck at 50 m.p.h. Static between the stations. Rain. We want to capture and control these sounds, to use them, not as sound effects, but as musical

> instruments. Every film studio has a library of 'sound effects' recorded on film. With a film phonograph it is now possible to control the amplitude and frequency of any one of these sounds and to give to it rhythms within or beyond the reach of anyone's imagination. Given four film phonographs, we can compose and perform a quartet for explosive motor, wind, heartbeat, and landslide.
> TO MAKE MUSIC
> If this word, music, is sacred and reserved for eighteenth- and nineteenth-century instruments, we can substitute a more meaningful term: organization of sound.
> WILL CONTINUE AND INCREASE UNTIL WE REACH A MUSIC PRODUCED THROUGH THE AID OF ELECTRICAL INSTRUMENTS
> [. . .]
> The special property of electrical instruments will be to provide complete control of the overtone structure of tones (as opposed to noises) and to make these tones available in any frequency, amplitude, and duration.[13]

Cage was here expressing a commonly held aspiration amongst avant-garde musicians and composers at the time, derived to a great extent from Russolo's manifesto. The composer Edgard Varèse was even replacing the word 'music' with the phrase 'organised sound'. However, during the early years of the twentieth century, the musical spirit that would ultimately form into 'electronic music' found itself stultified and frustrated by the limitations of both the technology and the conventions of the day. This is probably best exemplified by examining the careers of two visionary composers: Percy Grainger (1882–1961) and the aforementioned Varèse (1883–1965).

In the early 1890s the Australian, Grainger, had begun to dream of new technologies for music. He described a mechanically operated music desk that would do away with the need for a conductor, and first outlined his concept of 'Free Music', characterised by continuously gliding tones and an absence of regular rhythm. Grainger experimented with random composition in *Random Round* (1912) and wrote for highly unusual instrumental combinations, despite his successful career as a pianist and 'light music' composer. It was nevertheless many years before Grainger was able to build his own machines to perform the Free Music. A typical example is the *Kangaroo Pouch Machine* of 1948, which is essentially the controller of a collection of solovoxes (or theremins). Here, undulating pitch-control graphs and tone-strength controllers are made from paper wrapped around a revolving 'feeder' turret and passing through a metal cage to an 'eater' turret. These control eight oscillators, connected by electrical wires, which play the Free Music.

By the time Grainger was able to build his machines, there were probably technologies in existence which would have made the realisation of Free

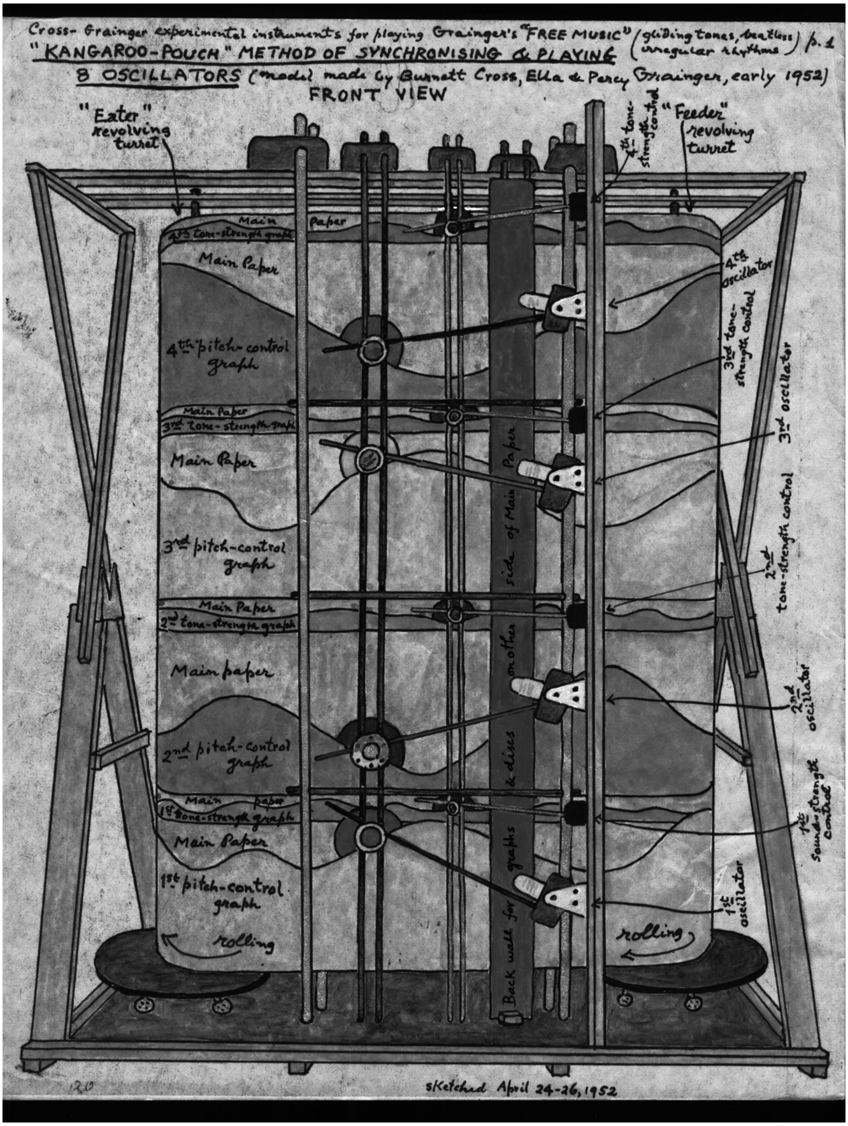

Figure 1.2 Percy Grainger's Kangaroo Pouch Machine (courtesy of The Percy Grainger Society/Estate)

Music more straightforward (although less delightfully idiosyncratic), but his determination to hear this electronic music in the way he had first imagined it was evidently the driving-force behind his persistence. The recordings that exist of these fleeting sonic experiments are rough, but repeated listening reveals a clear musical concept at work.

Varèse similarly spent the majority of his life dreaming of a day when the technologies available to him would be capable of realising his musical

Figure 1.3 Le Corbusier, Iannis Xenakis, Edgard Varèse: Philips Pavilion, 1958

ideas. As he remarked, bitterly: 'in music we composers are forced to use instruments that have not changed for two centuries.' In his manifesto 'The Liberation of Sound', published in 1936, he wrote:

> The raw material of music is sound. That is what the 'reverent approach' has made people forget – even composers. Today when science is equipped to help the composer realize what was never before possible . . . the composer continues to be obsessed by traditions which are nothing but the limitations of his predecessors . . .
>
> As far back as the twenties, I decided to call my music 'organized sound' and myself, not a musician, but 'a worker in rhythms, frequencies, and intensities.' Indeed, to stubbornly conditioned ears, anything new in music

> has always been called noise. But after all what is music but organized noises? And a composer, like all artists, is an organizer of disparate elements . . .
>
> The electronic medium is adding an unbelievable variety of new timbres to our musical store, but most important of all, it has freed music from the tempered system, which has prevented music from keeping pace with the other arts and with science. Composers are now able, as never before, to satisfy the dictates of that inner ear of the imagination. They are also lucky so far in not being hampered by aesthetic codification – at least not yet! But I am afraid it will not be long before some musical mortician begins embalming electronic music in rules.

With such passionate, even Romantic, views, it is no surprise that Varèse encountered constant obstacles to his musical expression. He composed only a handful of works, and he experienced rejection both by the general public and his professional colleagues (including Schoenberg). His attempts to convince Bell Laboratories to allow him to research electronic music during the 1920s and 1930s failed. It was only during his seventies that the musical world and the technological world caught up with Varèse. He composed *Déserts* for orchestra and tape in 1950–4, supported by Pierre Schaeffer who provided facilities at the Radiodiffusion-Télévision Française (RTF) studios, where he was working on musique concrète.

Finally, in 1958, Varèse was invited by the architect Le Corbusier to create *Poème électronique* for the Philips Pavilion at the 1958 World's Fair. This was essentially a sound installation, which used four hundred loudspeakers to create a walk-through sonic experience that combined synthesised and recorded and processed sounds. It is also in many ways the realisation of Bacon's 'sound-house'. This classic work remains highly influential today: a high point in the early development of electronic music. What Varèse's career demonstrates, however, is that the *origins* of electronic music lie much further back than this work, in the creative imagination of the artist.