BODY of KNOWLEDGE

Sounds from the Electrified Human Body: Reconfigurations of Embodied and Encultured Knowledge from the Development of Electrosomatophones

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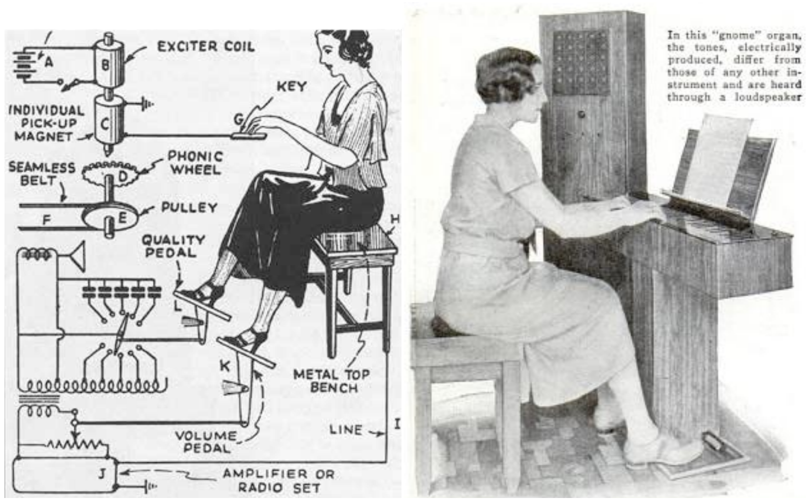
INTRODUCTION



In 1932 Ivan I. Eremeeff introduced the “Gnome”, an organ with stainless-steel keys that sends electrical oscillations for each pitch through the performer’s fingers to be mixed in their body and exit via a conduction plate in the bench and amplified, filtered and projected from a loudspeaker (Roads).

The “Gnome” exemplifies musical instruments that will be classified here as “electrosomatophones” - instruments that involve electrical interactions with human and other fleshy bodies. Electrosomatophones developed over the last 300 years include the Denis d’or of Václav Prokop Diviš in 1748, Gray’s devices of the late 1800’s, Theremin in the early 1900’s, Eremeeff, Trautwein and Lertes in the 1930’s, Le Caine in the 1950’s, Michel Waisvisz and Don Buchla in the 1960’s, Salvatori Martirano and the Circuit Benders in the 1970’s, this authors Fingerphone and the mobile phone “apps” of Smule Inc. in this decade.

The academic study of electrosomatophones is in its infancy so this preliminary paper points future scholars to the traces of objects of interest and introduces productive questions these instruments provoke for several related communities of interest.

DEFINITION

This definition of electrosomatophone affords useful flexibilities in our object of study:

Electrosomatophone: *sounding assemblage involving electrical charge and fleshy bodies.*

This definition affords the inclusion of touch-screen, mobile telephones that produce key-click sounds when their screens are tapped thereby exposing the double skeuomorphism of a visually-simulated typewriter keyboard and typewriter key-click sound. The musicality of sounds produced this way and the instrumentality of the assemblage cannot be assessed with the device itself. These are aspects of a larger context involving questions of performance and perceived performance. Mobile telephones are designed specifically to maximize the number of contexts they may be used in, so starting out with a broad definition of electrosomatophone invites concurrent perspectives from multiple fields including: sound studies, critical musicology, auditory display, and user experience design.

Figure 2 Physiological Music

"Physiological Music" depicted in Figure 2 provides us with an interesting edge case for our electrosomatophone definition. The electrical currents flowing through the dancers are modulated by the grooves of a gramophone record by way of a carbon microphone and an amplifying and isolating transformer. We might reasonably exclude this scenario from our term on the basis that no vibrations are produced acoustically so no sound–as it is usually defined–is involved. However, we have to be careful examining the historical trace not to overlook electrosomatophones when contemporary notions of what constitutes an acoustic transducer are absent from the trace. A significant example of this is Elisha Gray's patent from which the illustration of Figure 4 is taken.

In January 1874, Elisha Gray discovered his nephew amusing himself by taking electric shocks from one of his induction-coil interruptors and transducing sounds into a bathtub.

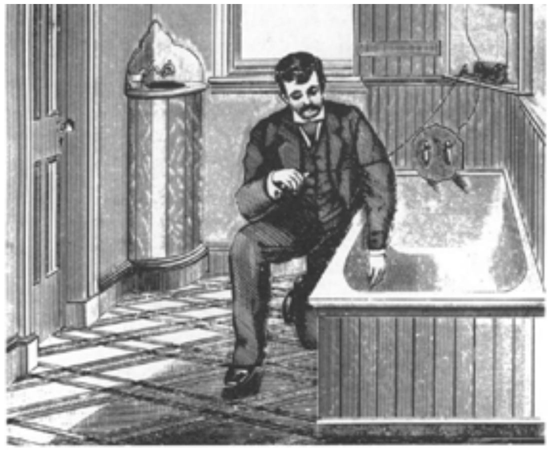


Figure 3: Elisha Gray's musical bath (Hounshell 1975)

This discovery precipitated refinements that included substituting the bathtub for a violin body with a conductive plate attached, and the filing and eventual issuing of a patent (GRAY 1875). Gray saw the discovery as having value in sending music across the telegraph network and in solving the problem of sending more messages down existing telegraph wires.

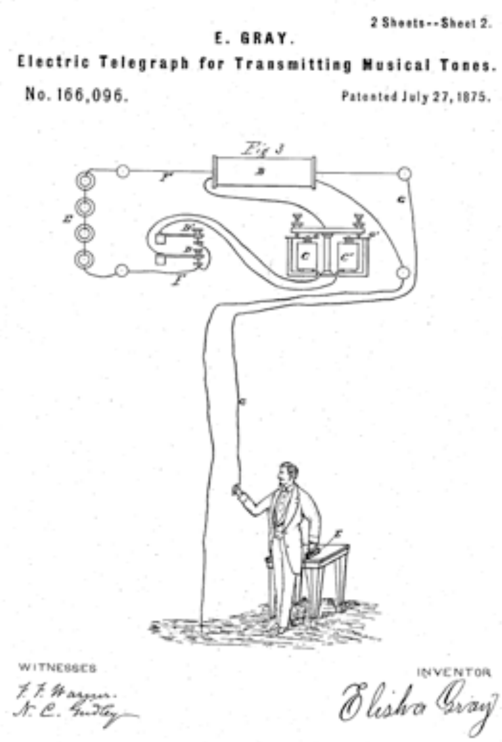


Figure 4: Incorporated Telecommunications. (GRAY 1875)

The following extract from Gray's patent hints at the extent to which fleshy components were an ordinary element of electrical engineering at the end of nineteenth century.

"These characteristics are found in the skin of the human body; in leather moistened with acidulated water, in animal flesh covered with a membraneous coating; in bacon-rind in pork-skin, especially pieces taken from the ear or tail; in kid gloves; and in other substances which need not be enumerated, as they do not operate so perfectly as those above given"

Gray 1875

INSTRUMENT BUILDERS

The definition of electrosomatophone I propose is intended to invite contemporary musical instrument and sounding object builders to explore, appropriate and acknowledge the long trace of components and praxis they employ. Paul Demarinis is a notable example of a contemporary artists who already does this as exemplified by his work "Gray Matter," a creative recrudescence of Elisha Gray's fleshy transducer experiments.

FLESHY BEGINNINGS

Human and animal bodies were always part of electrical circuit exploration from the beginning of the systematic development of circuits in the 17th century. Fundamental discoveries of electricity were produced, articulated and attested by integrating the living and dead flesh of human and other animal bodies into circuits. Examples of this include Watson's flying boy capacitors and switches, Galvani's frog motors, Franklin's batteries, Volta's pile, Pages' inductors, Meucci's telephone and the aforementioned musical telegraph of Gray.

The image of Figure 5 represents two storyboards for scenes in electrical shows performed throughout Europe and North America in the mid 1700's (Watson 1748).

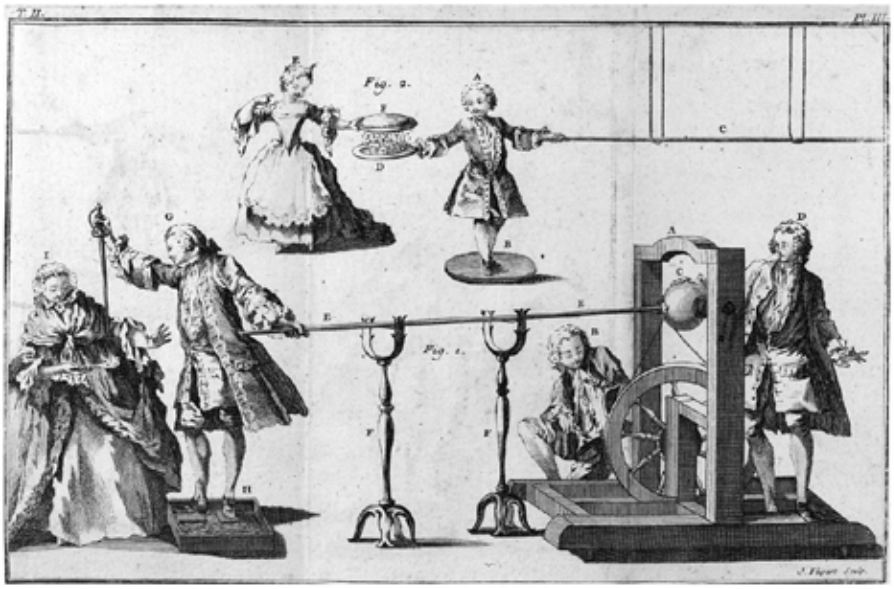


Figure 5: Storyboarding Shows of Electrical Wonder (Watson 1748)

The kinetic energy of the wheel (B) is transferred to the spinning amber or glass sphere where it is transformed into electrical potential energy (charge) by the process of rubbing the sphere with a material such as wool or silk (C). The charge is collected and stored on the "primary conductor" (E) that is supported on silk or other nonconductive bands above the ground. When the glass of spirits is brought close enough to the sword a circuit is complete allowing electrical charge to flow through the sword, the body of the swordsman, through a small region of the air (the spark gap) through the liquid, the tray and the tray holder's body to the ground. The tray H contains an insulating material preventing the current from flowing through the swordsman's feet directly to ground. The climax of this particular scene is that the alcohol bursts into flame.

Above this sword scene is a variant where the alcohol is replaced by a pile of chaff. The moment of wonder in this scene is when the chaff rises towards the lady as charge is dispersed across it because of the electric field between the conductive plates F and D.

The two storyboards involve different actors and a different staging but the basic story is the same in all of them: energy is transformed from mechanical to electrical, stored and then on cue, transformed to sound, heat, motion and/or light.

Among the 35 scenes Ebenezer Kinnersley advertised in a broadsheet for one of his famous electrical shows (Delbourgo 2006), 15 are scenarios with people or animals in the circuits. Often living beings are in danger – always a crowd pleaser.

Volta's first-person accounts of electrically-induced sensation are grounded in kinetic and kinaesthetic descriptions of phenomena experienced during interactions with his galvanic pile and water.

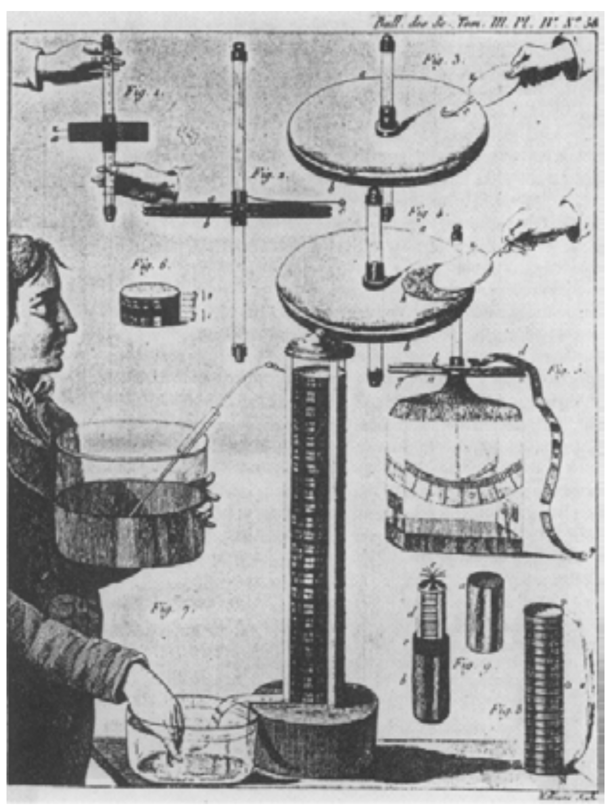


Figure 6. Volta experiencing his pile (Hallé 1801)

"*To obtain such slight shocks from this apparatus which I have described, and which is still too small for great effects, it is necessary that the fingers, with which the two extremities are to be touched at the same time, should be dipped in water, so that the skin, which otherwise is not a good conductor, may be well moistened. To succeed with more certainty, and receive stronger shocks, a communication must be made, by means of a metallic plate sufficiently large, or a large metallic wire, between the bottom of the column (that is to say, the lower piece of metal,) and water contained in a bason or large cup, in which one, two, or three fingers, or the whole hand is to be immersed, while you touch the top or upper extremity (the uppermost or one of the uppermost plates of the column) with the clean extremity of another metallic plate held in the other hand, which must be very moist, and embrace a large surface of the plate held very fast. By proceeding in this manner, I can obtain a small pricking or slight shock in one or two articulations of a finger immersed in the water of the bason, by touching, with the plate grasped in the other hand, the fourth or even third pair of metallic pieces. By touching then the fifth, the sixth, and the red in succession till I come to the last, which forms the head of the column, it is curious to observe how the shocks gradually increase in force. But this force is such, that I receive from a column formed of twenty pairs of pieces (not more) (shocks which affect the whole finger with considerable pain if it be immersed alone in the water of the bason; which extend (without pain) as far as the wrist, and even to the elbow, if the whole hand, or the greater part of it, be immersed and are felt also in the wrist of the other hand.*"

(Volta 1800), page 292

This account illustrates an important difference between a frog's leg and the experimenter as measuring instruments for electricity. The frog's response was so sensitive that it could be triggered by atmospheric electricity. It was really only useful as a detector. Volta's account describes the use of the body for a relative continuous measurement that also included a detection threshold (pain). Volta elaborates on this describing how the bodily instrument can be adjusted to make it more sensitive:

"Recurring to the sensation of pain which is felt in the experiments above described, I must add, that if this pain be very strong and pricking in the parts covered by the skin, it is much more so in those where the skin has been taken off— in recent wounds for example. If by chance there should be a small incision or bit of the skin rubbed off in the finger which I immerse in the water that communicates with one of the extremities of the electro-motive apparatus, I experience there a pain so acute, when, by establishing the proper communication with the other extremity, I complete the circle, that I must soon desist from the experiment; that is to say, must withdraw my finger, or interrupt the circle in some other manner. I will say more; that I cannot even endure it above a few seconds when the part of the apparatus which. I put in play, or the whole apparatus, contains only twenty pair of plates, or about that number."

(Volta 1800), page 304

The new scenes of wonder Volta promises involve a breathtakingly broad assault on the senses as well as use of electricity to interrogate the body. Some of these sorts of experiments had been reported with electrostatic power sources but Volta's instructions quoted below provided comparatively safer scenarios.

Taste

"In regard to the sense of taste, I had before discovered, and published in these first memoirs, where I found myself obliged to combat the pretended animal electricity of Galvani, and to declare it an external electricity moved by the mutual contact of metals of different kinds,—I

had discovered, I say, in consequence of this power which I ascribed to metals, that two pieces of these different metals, and particularly one of silver and one of zinc, applied in a proper manner, excited at the tip of the tongue very sensible sensations of taste; that the taste was decidedly acid, if, the tip of the tongue being turned towards the zinc,…

"if I advance the tip of my tongue gradually, that, when it has arrived within a very small distance of the metal, the electric fluid (I would almost say spark), overcoming this interval darts forwards to strike it"

(Volta 1800), page 305

Sight

"I was surprised to find that, with 10, 20, 30 pairs, and more, the flash produced neither appeared longer and more extended, nor much brighter than with one pair. It is true, however, that this sensation of weak and transient light, is excited by such an apparatus much easier and in different ways. To succeed, indeed, with one pair, the following are almost the only methods; viz. that one of the metallic pieces should be applied to the ball of the eye, or the eye-lid well moistened, and that it would be made to touch the other metal applied to the other eye, or held in the mouth, which produces a flash much more beautiful; or, that this second metallic piece should be held in the moistened hand and then brought into contact with the former; or, in the last place, that these two plates should he applied to certain parts of the inside of the mouth, making them communicate with each other."

(Volta 1800), page 30

"But the most curious of all these experiments is, to hold the metallic plate between the lips, and in contact with the tip of the tongue; since, when you afterwards complete the circle in the proper manner, you excite at once, if the apparatus be sufficiently large and in good order,

and the electric current sufficiently strong and in good order, a sensation of light in the eyes, a convulsion in the lips, and even in the tongue, and a painful prick at the tip of it, followed by a sensation of taste."

(Volta 1800), page 308

Hearing

"I introduced, a considerable way into both ears, two probes or metallic rods with their ends rounded, and I made them to communicate immediately with both extremities of the apparatus. At the moment when the circle was thus completed I received a shock in the head, and some moments after (the communication continuing without any interruption) I began to hear a sound, or rather noise, in the ears, which I cannot well define: it was a kind of crackling with shocks, as if some paste or tenacious matter had been boiling. This noise continued incessantly, and without increasing, all the time that the circle was complete, &c. The disagreeable sensation, and which I apprehended might be dangerous, of the shock in the brain, prevented me from repeating this experiment."

(Volta 1800), page 308

To adherents of embodied cognition Volta's accounts are delightfully free of preconceived notions of what electricity "is" or claims of where it might be situated as a given in the world. In his time there were many semblant manifestations of electricity produced by such diverse means (combining dissimilar metals, probing animal tissue, holding electric eels, spinning glass wheels, tapping lightning with kites etc.) that knowledge of electricity at that time is better described as distributed and shared descriptions of commonly experienced phenomena rather than a stable, compact, abstract conceptualization.

The Voltaic pile rapidly eclipsed the Leyden jar and prime conductor, providing experimenters, medical practitioners and demonstrators with an electrical source of higher energy levels available for sustained periods of time - days instead of the thousands of a second electrostatic sources of energy provided. This resulted in a small but significant shift in practice in the staging of electrical activity. With electrostatic machines climactic moments were controlled by closing a circuit. At the moment the circuit was reopened was of minor importance because the energy stored in the prime conductor was lost so quickly. With a continuous source of current from voltaic piles the breaking of the circuit now had to be carefully scripted. One scenario Volta describes is the use of pain as the signal of when to break the circuit.

Repeating this scenario represents a bodily inscription of the electrical relaxation oscillator invented by Andreas Gordon (Gordon 1745) and known as Franklin's bells. The relaxation oscillator scenario is replayed with electromagnetic props with the electric bell, some kinds of interruptors, the tremblor and electrotome, then in the twentieth century with neons and thyratrons in early electronic organs, and audions in radio transmitters and receivers.

CRISES

The wonder of many electrical demonstrations stemmed from the precision of the location of the electrically induced "crisis" an aspect carefully carried into the rhetoric (Adams, Jones, and Birch 1799) and practice of medical electricity and supported by instrument builders (Nairne 1787). This crisis model endured at least until 1932 as we can see from the electric bath of figure 7 where we are told that:

"an artificial fever is created by passage of current through the solution in which the patient rests his hands feet"

(1932)

Electric Bath Fights Disease

SOME London hospitals are now equipped with the latest in scientific methods of combatting disease, the electro-therapeutic bath.

The diseased patient sits comfortably, as the photo below shows, with his hands and feet in small tubs. The artificial fever is produced in the body by the passage of an electric current which combats the disease germs and hastens recovery.

The electric current is run into the solution in the tubs through electrodes. The intensity of the current can be altered by rheostats on the control board shown in lower left corner of the photo.

An artificial fever is created by passage of current through the solution in which the patient rests his hands and feet.

Figure 7: Electric Bath (1932)

Further examples of how widespread practice of bodily circuit integration was to electrical experimenters can be found in Page's "History of Induction" (Page 1867), a valuable source on electrical laboratory practice in the early 19th century. His reason to write a history was to establish the precedence of his own contributions over other pretenders in Europe. This required a painstaking (and probably self-serving) chronology with verifiable prior publications and quotations. The following extracts from early pages of this book show that by the 1830's both Voltaic piles and bodily measurements of electricity were routine among many notable experimenters. Note that these experimenters had the resources to own expensive measuring devices that they used concurrently with the body:

Paraphrasing a report by Faraday of work in 1831:

"slight spark by using charcoal points"

"convulse frog's leg"

"slight sensation upon the tongue"

(Page 1867, page 5

Faraday:

"I could obtain no evidence by the tongue, by spark or by heating of fine wire or charcoal, nor could I obtain any chemical effects" the current was indicated only by the galvanometer and its magnetic effects",

(Page 1867, page 6

William Jenkins to Faraday:

"if the wire which surrounds an electro-magnet be used, a shock is felt each time the contact with the electromoter is broken, provided the ends of the wire be grasped, one in each hand"

(Page 1867, page 8

Henry in1835:

"with a large colorometer of eight pairs, shocks were felt as far as the elbow"

(Page 1867, page 8

Dr Neef in1835:

"Novel and important physiological effects due the rapid succession of small shocks. It was contemplated by Dr. Neef for use for medical purposes"

(Page 1867, page 9

Of Dr. Neef in 1839 inventing the:

"automatic circuit breaker, suggested the use of galvanic baths now so much in vogue.

(Page 1867, Page 9

Figure 8: Electric Wonder Bath (Baille and Armstrong 1872), page 207

PROHIBITIONS

Public demonstrations of electrified bodies were largely abandoned in the early 1900's as electrical engineering professionalized, electrical power levels increased, electrocutions terrified, and doctors prohibited.

Figure 9: Never Touch (Anonymous 1917) page 22

While industries, governments and professions did devise and mandate ways to discourage the public's direct contact with electricity, they were not successful at restricting the circulation of knowledge and materials or discouraging a vibrant "amateur" community of transgressive experimentalists. The names have changed: hobbyist, enthusiasts, bricoleurs, boffins, hackers etc. Exploring the way these sub-cultures define themselves and are seen by non-members is a valuable study in itself. The big challenge for historical perspective for this work is identifying a trace of the actual activities of adherants. One useful source to consider are the publications developed to appeal specifically to these communities. In the USA, Gernsback's many publications are a good starting point. For example, in Gernsback's 1938 publication: "Educational Library No 6: How to have Fun with Radio," 4 out of the fourteen projects proposed involved electrified bodies. The cover illustration, the "Talking Gloves," depicts two men holding wires from a radio set and communicating sound to a woman by holding their free, gloved hands to the woman's ears.

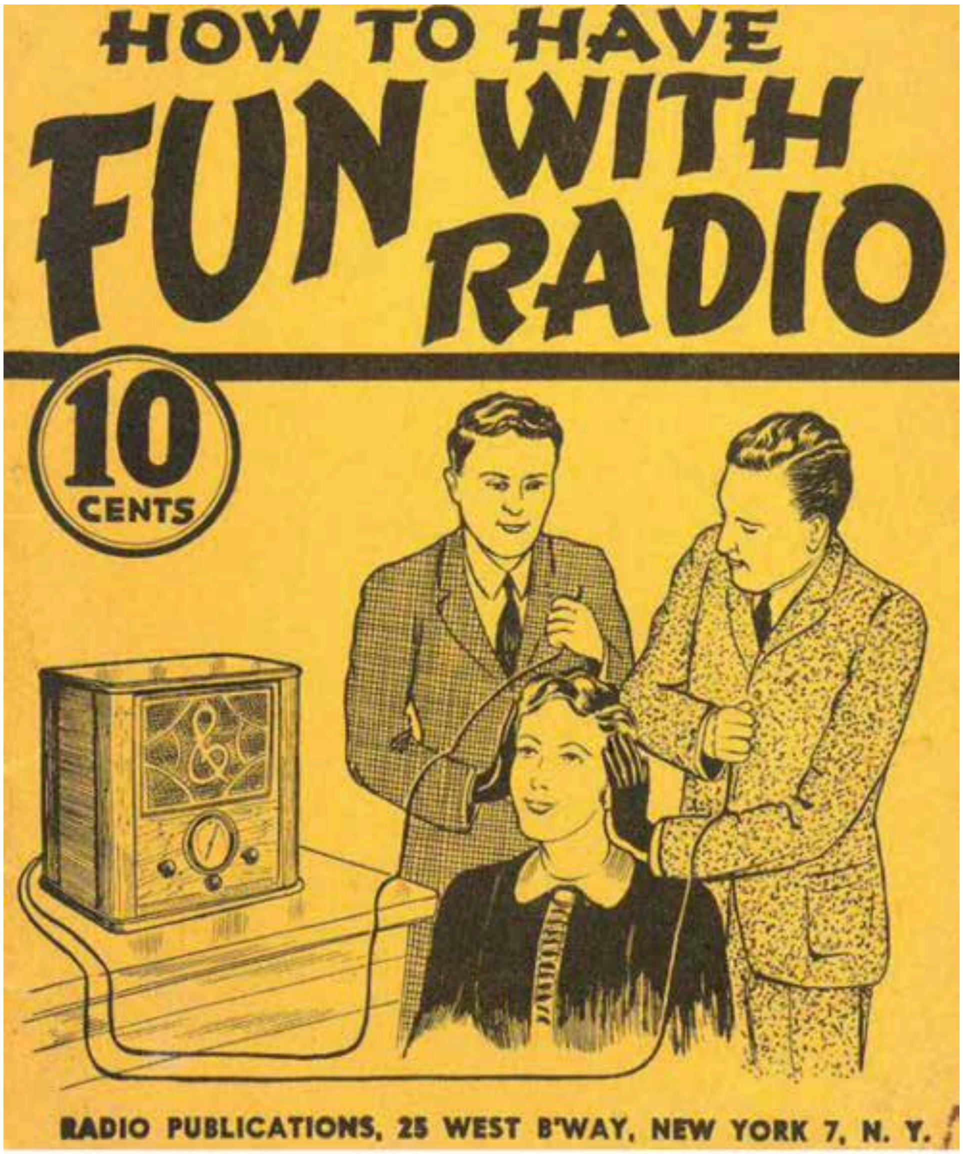


Figure 9: Gernsback's Booklet.

The challenge to keeping this situation "fun" for all involved is to avoid the flow of electricity between the participants. The idea is to use bodies to move the charge to the point in the circuit where mechanical motion can produce sounds. As Gernsback puts it:

"The radio set of today often has quite a bit of power in the output stage. You are and your assistant are therefor advised not to touch each other and not to touch the subject with anything other than the leather of the gloves."

(page 4).

These transgressive, dangerous aspects were presumably appealing to Gernsback's readers as themes of trickery, surprise and danger pervade the descriptions of the "fun" projects in this booklet. Comparable transgressive narratives appear for Michel Waisvisz's influential cracklebox electrosomatophone:

"Sometime in the early-sixties I started touching the inside of my father's short-wave radio receivers. Before that with my brother René I had given 'concerts' at home by placing our fingers on circuit boards of transistor radios that were 'wrongly', but usefully, interconnected with wires. The little electrical shocks were nice and the changes in the sound were exciting and magic mind-openers. Through touch I was able to start playing with short wave sounds in a way that would later become 'sound music'."

2004 http://www.crackle.org/CrackleBox.htm

There is a remarkable congruence between this account and accounts of the Denis d'or of the mid 18th century which produced electrical shocks for the player and used electrostatically charged iron strings. Unfortunately, we have of no trace of the Denis d'or or a detailed account of its operating principles. Enthusiasts of speculative "reconstructions" of old instruments could usefully explore whether the timbre or decay rates of iron strings of that era can be modulated by storing charge on them and whether controlled discharges of electricity on the strings is a workable alternative to plucking or hammering them.

The development of electrosomatophones, was not slowed by the establishment of prohibitions against direct human contact with the “electrical fire”, but prohibitions and taboos induced a change in engineering practice: a movement from direct current flows through bodies to electrical field modulations of the body–as typified by the Theremin of 1920 and the musical instrument “apps” that use the touch screens of today’s mobile telephones. Visceral experience of electricity is attenuated by this move to very low currents and electric field interactions.

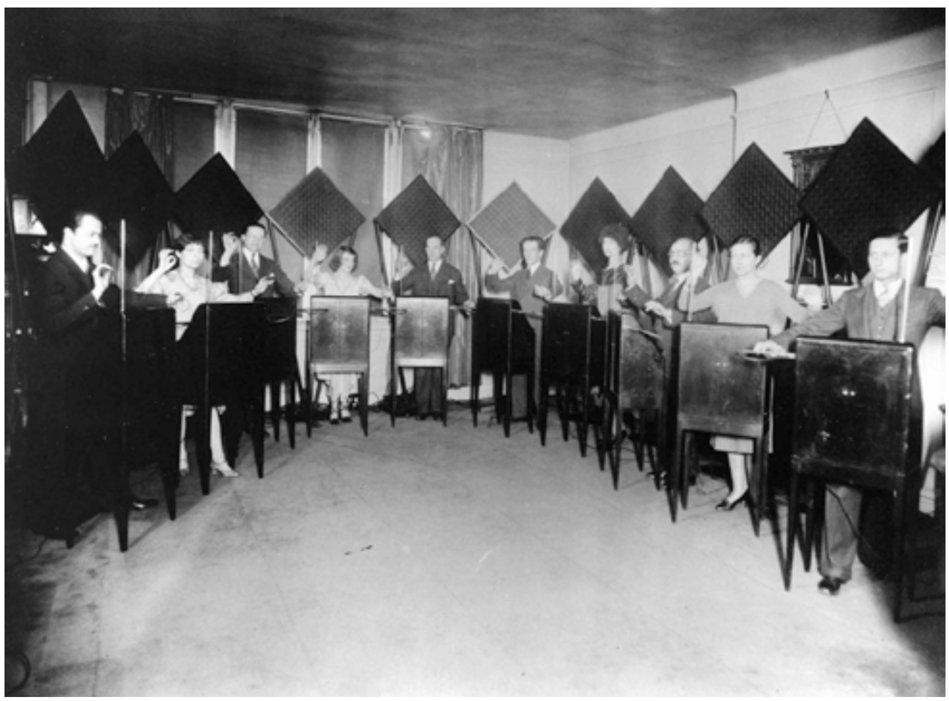


Figure 10: Theremin Ensemble

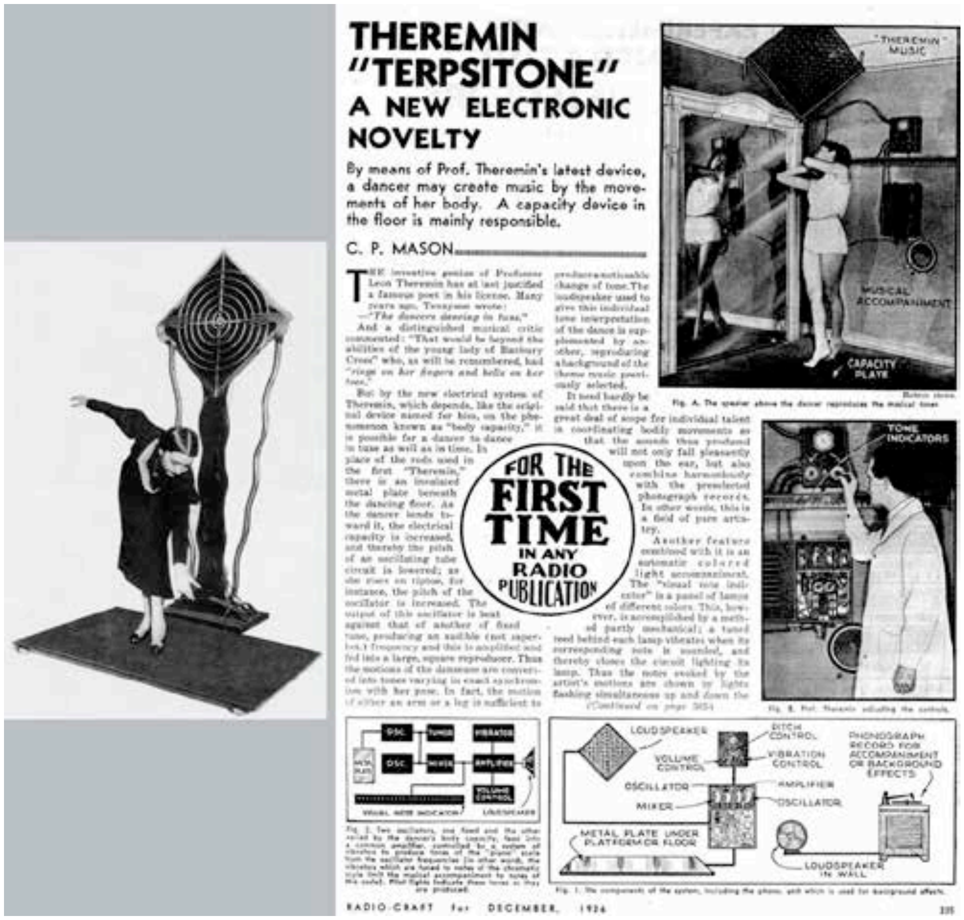


Figure 11: Theremin's Terpsitone

CONCLUSION

Cultural uptake of electrosomatophones has generally been poor, and yet musical "apps" available on billions of cell phones suggests that the latest electrosomatophones will have very strong uptake. The most well-known instrument in the category, the Theremin, while emblematic of electronic musical instruments is relatively rarely played. Accounting for these apparent contradictions requires careful exploration of the context in which the instruments were invented, innovated and received. A crucial pivot for these explorations is the long and ongoing struggle to understand and organize knowledge of electricity itself.

BIBLIOGRAPHY

1932. "Electric Bath Fights Disease." *Popular Mechanics*.
Adams, G, W Jones, and J Birch. 1799. *An essay on electricity: explaining the principles of that useful science, and describing the instruments, contrived either to illustrate the theory, or render the practice entertaining : illustrated with six plates. To which is added, a letter to the author, from Mr. John Birch, surgeon, on the subject of medical electricity*: Printed by J. Dillon, and Co., for, and sold by W. and S. Jones, http://books.google.ca/books?id=wws5AAAAMAAJ.
Anonymous. 1917. "118 Volts Can Kill." *The Electrical Experimenter*.
Anscombe, G. E. M. 1958. "On Brute Facts." *Analysis* 18:69-72.
Armstrong, E. H. 1915. "Some Recent Developments in the Audion Receiver." *Proceedings of the Institute of Radio Engineers* 3:215-238.
Baille, JBA and JW Armstrong. 1872. *Wonders of electricity*: Scribner, Armstrong, and co., http://books.google.ca/books?id=gC4XAAAAYAAJ.
Barneveld, W. 1785. *Geneeskundige electriciteit*: By J.B. Elwe en D.M. Langeveld, http://books.google.ca/books?id=5roZQgAACAAJ.
Bernardi, Walter. 2001. "The controversy over animal electricity in 18th-century Italy : Galvani, Volta and others." http://ppp.unipv.it/Collana/Pages/Libri/Saggi/NuovaVoltiana_PDF/quattro.pdf
Bertucci, P. 2006. "Revealing sparks: John Wesley and the religious utility of electrical healing." *The British Journal for the History of Science* 39:341-362.
Catania, B. 2003. "Antonio Meucci: how electrotherapy gave birth to telephony." *European Transactions on Telecommunications* 14:539-552.
Cavicchi, E. 2006. "Nineteenth-century developments in coiled instruments and experiences with electromagnetic induction." *Annals of Science* 63:319-361.
Cavicchi, E. 2008. "Charles Grafton Pageís Experiment with a Spiral Conductor." *Technology and Culture* 49:884-907.
Delbourgo, James. 2006. *A most amazing scene of wonders : electricity and enlightenment in early America*. Cambridge, Mass.: Harvard University Press.
Deleuze, Gilles and FÈlix Guattari. 1987. *A thousand plateaus : capitalism and schizophrenia*. Minneapolis: University of Minnesota Press.
Forster, MBM. 2002. "The Enigma of Volta' s "Contact Tension" and the Development of the "Dry Pile"." Pp. 103-119 in *Nuova Voltiana: studies on Volta*

and his times, edited by F. Bevilacqua and L. Fregonese: Universiti degli studi di Pavia.

Franklin, B and J Sparks. 1837. *The works of Benjamin Franklin; containing several political and historical tracts not included in any former edition, and many letters, official and private, not hitherto published; with notes and a life of the author*: Tappan, Whittemore, and Mason, http://books.google.ca/books?id=vVc-AAAAYAAJ.

Galvani, L. 1792. "De viribus electricitatis in motu musculari commentaries cum Joannis Aldini dissertatione et notis." *Mutinae: A pud Societatem Typographicam*.

Gordon, A. 1745. *Versuch einer Erkl√§rung von den Ursachen der Elektricit√§t*http://books.google.ca/books?id=MpQ5AAAAcAAJ.

GRAY, E. 1875. "IMPROVEMENT IN ELECTRIC TELEGRAPHS FOR TRANSMITTING MUSICAL TONES."

Hallé, J. N. 1801. " Exposition abrégée des principales expériences répétées par Volta en présence des commissaires de l'institut, etc." *Bulletin Des Sciences* 3:74-80.

Hounshell, DA. 1975. "Elisha Gray and the telephone: On the disadvantages of being an expert." *Technology and Culture* 16:133-161.

Kipnis, N. 2003. "Changing a theory: The case of Volta's contact electricity." *Volta and the history of electricity.*:17-36.

Lakoff, G and M Johnson. 1999. *Philosophy in the flesh: The embodied mind and its challenge to western thought*: Basic Books.

Marvin, C. 1990. *When old technologies were new: Thinking about electric communication in the late nineteenth century*: Oxford University Press, USA.

Mertens, Joost. 1998. "Shocks and Sparks: The Voltaic Pile as a Demonstration Device." *Isis* 89:300-311.

Mills, Allan. 2008. "Studies in electrostatics - Part 6: The Leyden jar and other capacitors." *Bulletin of the Scientific Instrument Society* 99:20-22.

Musschenbroek, P, J Musschenbroek, and P Massuet. 1719. *Essai de physique*: Chez Samuel Luchtmans, http://books.google.ca/books?id=f40PAAAAQAAJ.

Nairne, E. 1787. *The description and use of Nairne's patent electrical machine: with the addition of some philosophical experiments and medical observations*: Printed for Nairne and Blunt, http://books.google.ca/books?id=PVj1YQEACAAJ.

Otis, L. 2001. *Networking: communicating with bodies and machines in the nineteenth century*: The University of Michigan Press, http://books.google.ca/books?id=VEimJkOmW1kC.

Page, Charles Grafton. 1867. *History of induction : the American claim to the induction coil and its electrostatic developments*. Washington: Intelligencer printing house.

Pancaldi, Giuliano. 1990. "Electricity and Life. Volta's Path to the Battery." *Historical Studies in the Physical and Biological Sciences* 21:123-160.

Priestley, J. 1775. *The history and present state of electricity: with original experiments*: Printed for C. Bathurst, and T. Lowndes ... J. Rivington, and J. Johnson ... S. Crowder, G. Robinson, and R. Baldwin ... T. Becket, and T. Cadell, http://books.google.ca/books?id=20lkAAAAMAAJ.

Roads, Curtis. 1996. *Early electronic music instruments: Time line 1899-1950, Computer Music Journal,* vol. 20, pp. 20-23.Roberts, Lissa. 1999. "Science Becomes Electric: Dutch Interaction with the Electrical Machine during the Eighteenth Century." *Isis* 90:680-714.

Schiffer, Michael B., Kacy L. Hollenback, and Carrie L. Bell. 2006. *Draw the lightning down : Benjamin Franklin and electrical technology in the Age of Enlightenment*. Berkeley, Calif.; London: University of California.

Schiffer, Michael Brian. 2002. "Studying Technological Differentiation: The Case of 18th-Century Electrical Technology." *American Anthropologist* 104:1148-1161.

Society, Royal, C Hutton, G Shaw, and R Pearson. 1809. *The Philosophical Transactions of the Royal Society of London, from Their Commencement, in 1665, to the Year 1800: 1735-1743*: Printed by and for C. and R. Baldwin, http://books.google.ca/books?id=czpKAAAAYAAJ.

Solomon, JR and CG Martin. 2005. *Francis Bacon and the refiguring of early modern thought: essays to commemorate The advancement of learning (1605-2005)*: Ashgate Pub., http://books.google.ca/books?id=dBsAm8oQjrkC.

Stewart, Larry. 2004. "Science and the eighteenth-century public." Pp. 240 in *The Enlightenment world*, edited by M. Fitzpatrick: Routledge, http://books.google.ca/books?id=k-B-1fCfk0kC.

Sulzer, JG. 1762. *Theorie der angenehmen und unangenehmen Empfindungen*. Berlin
http://books.google.ca/books?id=F80AAAAAcAAJ.

van Barneveld, Willem. 1787. *Medizinische Elektrizität*http://books.google.ca/books?id=sQc9AAAAcAAJ.

Volta, A. 1800. *Philosophical magazine*, vol. 7: Taylor & Francis., http://books.google.ca/books?id=v2Bb30r1Z6QC.

Volta, A and J Banks. 1800. "I. On the electricity excited by the mere contact of conducting substances of different kinds." *Philosophical Magazine Series 1* 7:289-311.

Watson, William. 1748. *Expériences et observations pour servir à l'explication de la nature et des propriétés de l'électricité*http://cnum.cnam.fr/SYN/12CA29_1.html

.